SCIENCE IN AFRICA

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A REVIEW OF SCIENTIFIC RESEARCH RELATING TO TROPICAL AND SOUTHERN AFRICA

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FOREWORD

At an early stage in the collection of material for the purpose of the African Research Survey, it was decided to commission a number of preparatory studies of subjects on which material was not readily available; among other such studies, Dr. E. B. Worthington, a Cambridge Zoologist with experience of responsible field work in Africa, was asked to prepare a report on the progress of scientific research which had a bearing on Africa. This work was begun in the autumn of 1933. The first draft appeared to the members of the Committee in charge of the Survey to contain material which merited separate publication, as a supplement to the report of the Survey, and Dr. Worthington was requested to complete his work with this object in view.

The Survey method was chosen with deliberation. It would have been possible to invite a number of specialists in different countries to contribute summaries of research in their respective branches of science. Since, however, the purpose of the African Survey was to present, within a limited compass, a general review of the many problems involved in a number of different territories, it was felt that an account of scientific activity conceived in similar terms would be more likely to achieve the objectivity, scale and proportions required.

Such a method has its own disadvantages. The presentation of sciences other than his own by a specialist in one of them will inevitably differ materially from accounts by experts in each of those sciences, particularly if an attempt is made to write for the lay reader. It is not to be expected that all the disadvantages have been successfully avoided. We can, however, point to the fact that this is the first attempt to render some account of the extent to which scientific knowledge and research are being applied to the continent of Africa.

For the contents of the book the Committee owe a debt which cannot be overstated to the many specialists in all fields, who have assisted in the preparation of the first draft, criticized it at an early stage, and given extensive help by subsequent checking of facts, bibliographies, and the like. While none of them have responsibility for the contents of this volume, it is, in itself, a monument to their labours, and we must ask their indulgence if, in compressing so much into a relatively small space, we have failed to do full justice to the material which they have supplied.

The development into an independent volume of what was originally undertaken as a factual memorandum for the purpose of the Survey, has involved certain changes of form. Any opinions which are expressed are those of Dr. Worthington himself, for which he takes full responsibility; but I desire to acknowledge here the value of the contribution he has made to the work involved in the preparation of *An African Survey*, in which the report of the African Research Survey has been embodied. The preparation of this volume, as a part of the work of the African Research Survey, has been made possible through the generosity of the Carnegie Corporation of New York. They do not, however, accept any responsibility for statements or opinions contained in it.

HAILEY

31 July 1938

AUTHOR'S PREFACE

This book is one of a series of reports prepared in connection with the African Research Survey.[1] The problems of Africa, as they present themselves to those whose concern is with the development of the continent, are discussed in *An African Survey*. The purpose of this volume is to summarize the present position of studies in the various sciences which have a bearing on African conditions. As far as possible the more important work up to 1936 has been mentioned; in the sections dealing with medical research, however, it has not been possible to give a complete account of work done after 1934.

As a zoologist by profession and acquainted at first hand with African research only in connection with biology and the fisheries of the great lakes, I can offer no authoritative opinions on most of the subjects discussed. Accordingly, I am indebted to those authorities whose names are listed on pages 615 to 625, with a note of the chapters in which their help has been specially valuable. I should like to express my thanks for the generous way in which they have placed their time and experience at my disposal. At the same time, I do not wish by the mention of any individual, institution or government department in this list of acknowledgements to engage their responsibility for opinions expressed or the accuracy of any statement made.

I had the advantage of joining Lord Hailey, the Director of the African Research Survey, for the last part of his tour through Africa in 1935–6, and of travelling with him through Nigeria, Dahomey, Togoland, the Gold Coast, Sierra Leone, the Gambia, Senegal, and the French Sudan. Previous work in connection with the great lakes had given me some knowledge of East Africa.

As many of the subjects dealt with in this volume are still

[1] See *An African Survey*, Oxford, 1938.

necessarily matters of controversy, an attempt has been made to state the views of experts as objectively as possible, without attempting to assess the merits of rival theories. As far as possible the material has been arranged uniformly in each chapter, under the headings of introduction, organization, and results. Territorial arrangement has been followed when subjects lent themselves to such treatment.

Unfortunately shortage of time has resulted in the omission of much interesting work, particularly in the Union of South Africa and in the French territories, and there is consequently a lack of proportion in the treatment of some subjects. Much as I regret this, it seemed preferable to a general scaling down of the volume in order to preserve a more even balance.

In addition to those mentioned in the list, I would like to thank Lord Hailey and the members of the African Research Survey Committee, as well as Miss Hilda Matheson, for help and advice in all stages of the work; Professor J. Stanley Gardiner for reducing my duties in the Zoological Department at Cambridge to a minimum, so that I have been enabled to spend as much time as possible on this work; the Conference of East African Governors, for providing me with a research assistant, so that studies of African lakes have been continued at the same time; my wife, for much assistance in extracting information and translating foreign memoranda; Miss J. L. Hopkins, for performing many duties which usually fall outside the scope of secretarial assistance, and Mrs. R. M. C. Fasnacht for preparing the index. When preparing the final draft for press Dr. L. Mair and Dr. M. Lambert very kindly revised the whole volume from an editorial viewpoint, and most of the chapters were submitted to individual experts for final comment and revision, in some cases involving considerable additions and corrections. These experts, to whom thanks are specially due, were as follows (the numbers in brackets indicating the chapters examined): Sir A. Richard Gregory, Bt., F.R.S. (I), Brigadier M. N. MacLeod, D.S.O., M.C. (II), Professor O. T. Jones, F.R.S. (III), Mr. L. W. C. Bonacina (IV), Sir E. John Russell, F.R.S. (V and XI), Dr. G. V. Jacks (V), Mr. A. D. Cotton, O.B.E. (VI), Mr. J. N. Oliphant, Professor R. S. Troup, C.M.G., C.I.E., F.R.S., and Dr. J. Burtt Davy, F.R.S. (VII), Dr. Julian S.

Huxley, F.R.S. (VIII), Sir Guy A. K. Marshall, C.M.G., F.R.S. and Mr. B. P. Uvarov (X), Mr. H. C. Sampson, C.I.E. (XI, XII, and XIII), Dr. F. C. Kelly, Professor F. A. E. Crew and Mr. A. D. Buchanan-Smith (XIV), Dr. H. H. Scott (XV, XVI, and XVII), and Dr. L. Mair (XVIII). I must again emphasize that the mention of their names in no way commits them to responsibility for opinions expressed or factual accuracy.

The photographs were taken by the author during the tour of the African Research Survey, with the exception of the lower photographs of Plates II and VIII, for which I am indebted to Dr. P. W. Richards and Dr. Cicely Williams respectively.

E. B. Worthington

September 1938

NOTE ON REFERENCES

THE bibliography, which is intended to be representative rather than comprehensive, is arranged at the end of the volume under chapter headings. Thus it can be used either in connection with the text or independently as an indication of the more important literature available on each subject. Reference in the text is made by author (or source of origin when anonymous) and date according to the system usually adopted in scientific literature. Details of the system are explained in a note on p. 614, preceding the bibliography.

The African Research Survey is deeply indebted to the Librarians at many Institutions for answering queries, lending material, and giving facilities for reference.

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CHAPTER I

SOME PROBLEMS OF RESEARCH

INTERRELATIONS BETWEEN BRANCHES OF SCIENCE

BEFORE discussing in detail the problems of the separate sciences, it is necessary to consider certain general principles of research. In the first place the view is generally held that so long as facilities for research are limited, studies which are likely to lead to the promotion of human welfare, whether of native Africans or of immigrant races, should take precedence. Any work directed towards this process of 'bonification' is bound to influence and be influenced by that done on allied problems, so that in deciding the subjects to be selected for special attack a review of the whole field is necessary. The following diagram is designed to show in broad outline the interrelations of the subjects considered in this volume, and to explain the order in which they are treated.

An attempt has been made to arrange the subjects in such a way that each topic discussed depends on those which have gone before. Thus knowledge of the configuration of the land (Surveys and Maps, II) necessarily precedes the study of the structure of the rocks comprising it (Geology, III) and of the atmosphere above it (Meteorology, IV). But the surface configuration is itself determined by geological structure and climate, and this is indicated in the diagram by connecting arrows pointing in both directions. These three subjects, constituting the physical basis of the environment, include that all-important factor in Africa—water-supply. The combination of water-supply and ground structure is responsible for the character of the soil (Soil Science, V), which in turn determines and is determined by the flora growing upon it (Botany, VI). From the wild flora we proceed to the two main applied branches of botanical study, Forestry (VII) and Plant Industry

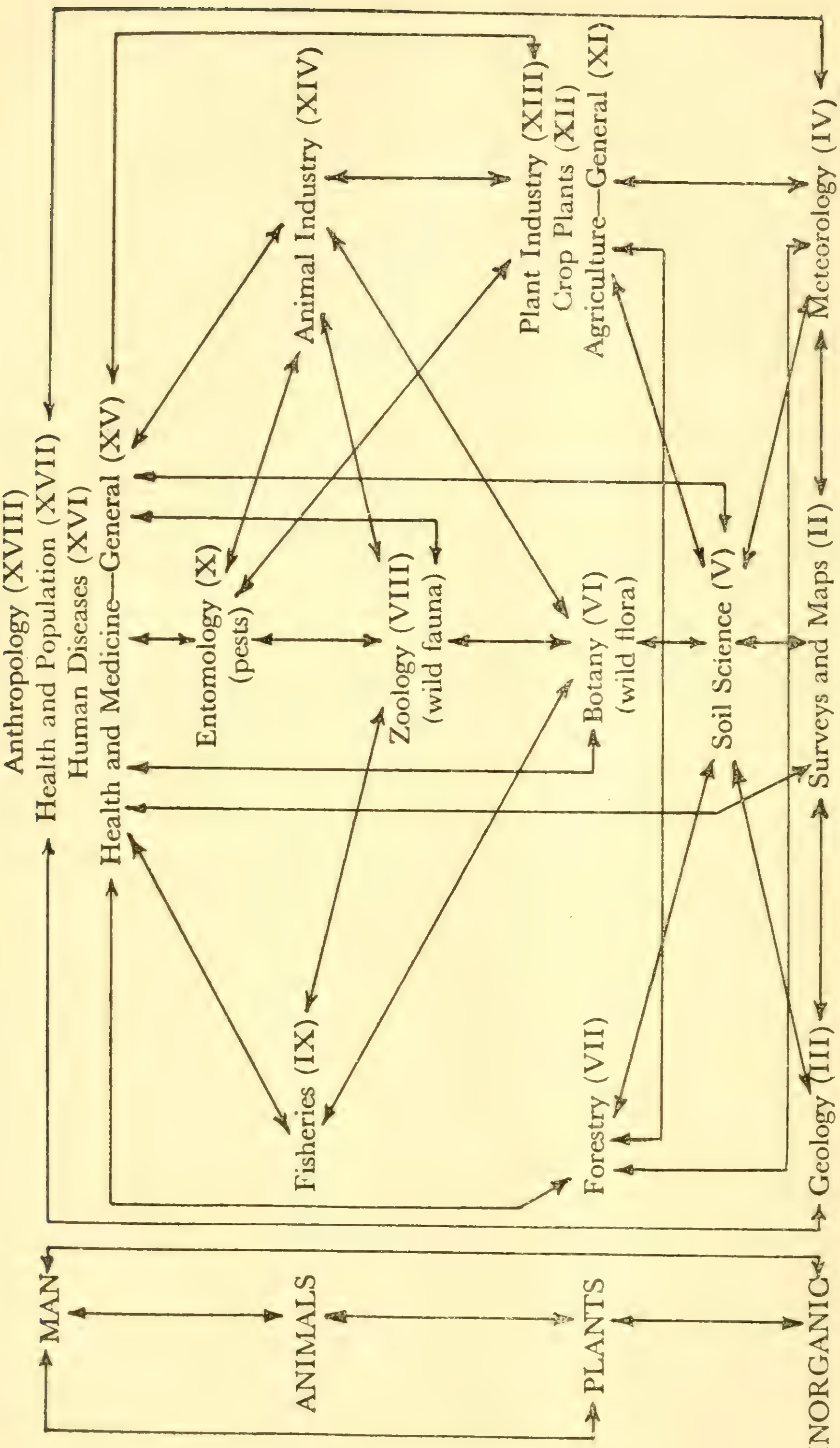


Diagram to show the principal relations between the subjects considered in this volume.
(The figures in brackets denote chapter numbers.)

(XI, XII, XIII). Again, studies of forestry and agriculture are relevant to the problems created by the native practice of shifting cultivation. They are connected with soil science through the effects of excessive destruction of pests and intensive cultivation upon soil erosion, and with meteorology through the interaction of these factors with the rainfall.

All the animal kingdom, whether wild, domestic, fish, insects, or man himself, must depend directly on plants for food, since plants are the only agents for building inorganic into organic substances. Thus all the upward-pointing arrows in the upper part of the diagram represent food relations. There are also, however, backward effects: the wild animals (Zoology, VIII) and domestic animals (Animal Industry, XIV) affect the wild and domestic plants by consuming them and by manuring the soil in which they grow; aquatic animals (Fisheries, IX) have similar relations with the flora of the ocean, lakes, and rivers; and insect pests (Entomology, X) affect not only man and animals, but forest trees and crops. Finally the study of man himself (XV–XVII) is related to that of every aspect of the environment, either through the conditions of health and nutrition which it imposes on him or through activities such as agriculture, forestry, and mining by which he modifies it.

Although in setting forth the recent advances in these subjects, the individual sciences have to be treated separately, it cannot be too strongly urged that their interrelations have important practical applications; progress in one field may often be hampered through neglect of related studies.

Africa as a field for pure as opposed to applied science, if such a distinction can be drawn, is almost infinite, and only the boundaries have yet been explored. In a work of this nature but little space can be devoted to fundamental problems of science such as the shape and structure of the earth, the processes by which the continents have reached their present configuration, the mechanism of evolution, or the early ancestry of man. Africa has already contributed its quota to the solution of such questions, and references to the work accomplished have been incorporated where possible.

THE CHANGING ENVIRONMENT

As an aid to the appreciation of the interdependence of scientific studies in Africa, some description may be given of the main aspects of the African environment with the changes which they are undergoing at the present time.

Under natural conditions, the forms of plant and animal life which survive in a particular régime represent a kind of 'balance of nature' in which constructive and destructive factors are in general equilibrium. The balance involves both the vitality of organisms and their surroundings. Environmental changes can be classed in the same categories as are used in the diagram on page 2. In a mechanical sense the balance of nature is not a simple balance, but a complex system of levers and links all balanced with each other, so that extra weight placed on any part of the system may cause the whole to change its equilibrium. First, the structure of the surface and of the underlying rocks may be taken together. These parts of the environment typically exhibit very slow change, such as steady erosion, which carves out valleys, leaving mountains between, the rending of the surface to produce rifts, and the building-up of volcanoes. Such changes have undoubtedly had great effect on the evolution of early man, but they can be disregarded when considering the present and the immediate future, except in so far as the acceleration of erosive processes can, under certain circumstances, lead to the direct loss of soil.

Measurement of the surface configuration leads to the production of accurate maps. At first sight this again cannot have much effect on the African, but on it depend many of the developments of civilization which are already causing most drastic changes to his environment, for example, railways and roads. Furthermore, the study of the physiography of rivers from precise levelling and the measurement of their flow is leading to the development of irrigation, and of all changes to the environment the irrigation project, coupled with settlement schemes, calls upon the most extreme adaptability of the African. Thus the Gezira irrigation scheme in the Sudan has produced great changes in the social structure of the agriculturalists involved. As another example, the great irrigation projects of the French in the region of the Middle

Niger may be cited; vast areas of desert country are there being put into intensive cultivation by the construction of barrages and feeder canals, but there is no settled agricultural population in the immediate neighbourhood. It is necessary, therefore, to convert nomad pastoralists into fixed cultivators, and it is even proposed to transplant some of the dense population of Algeria to this region, separated as it is from their home by the Sahara Desert. Other schemes have been suggested in the native reserves of East Africa; for example a recent study of the Tana River showed how a large area, at present ravaged by soil erosion, could be changed into a centre of permanent settlement by an irrigation work. It is significant here that nothing further can be done until the whole region is mapped to a degree of accuracy far surpassing that of the present.

Another question in which the measurement of Africa's surface is all important, is that of the exploitation of mineral resources. The momentous changes in environment which this has made are more prominent in southern Africa than elsewhere, but there is no reason to suppose that the rocks of South Africa are more rich in valuable minerals than those of the tropical regions. The greater degree of change so far produced in South Africa is due solely to the greater efforts that have there been devoted to the discovery of minerals.

Of all environmental factors, water-supply is the most important because it controls all plant and animal life. In general the character of vegetation and the crops which can be raised are determined not by the total rainfall so much as by its distribution through the year. Thus the double maxima of rainfall occasioned by the type of atmospheric circulation in tropical latitudes, where the sun passes vertically overhead twice during the year, involve a double climax in vegetable growth, and hence in agriculture. Local climatic conditions, however, sometimes obliterate one of the rain maxima in certain areas, such as the belt of country between the Guinea lands and the Sahara, which includes the French Sudan, the northern parts of Nigeria, the Gold Coast, Dahomey, etc. In all this belt, human activity follows a single cultivation cycle during the year. We can state that in any given set of conditions which are constant from year to year, an agricultural or pastoral people will evolve suitable methods of cultivation

or husbandry: for example, in the more arid regions pastoralists migrate with their cattle back and forth to the wet-season pastures, resorting during the dry season to country where a permanent water-supply remains. What happens then when this annual regimen of rainfall and water-supply changes, and in fact, does it change?

In answer to this question it is only possible to mention the supposed progressive desiccation of Africa: to point out that the continent is still emerging from the last pluvial period; that river-capture has caused many internal drainage basins to run out to sea; that some believe the Saharan sands to be shifting slowly southwards; that the filtering action of swamps tends to the production of dry land; and finally, but more important still, to point to the effects of human activity in accelerating run-off by the destruction of forests, overcultivation and overgrazing.

Apart from this general change to drier conditions, if such exists, there are undoubtedly minor changes in rainfall of a secular or perhaps cyclical nature. The period of records is too small to show whether the Brückner cycles with a periodicity of about thirty-five years, which have been traced back in Europe through several centuries, also exist in Africa. It is generally supposed that the Brückner cycles are less well marked in tropical than in temperate regions; but the eleven-year cycle of solar activity, represented by a periodic increase and decrease in the number of sunspots, is said to show up better in the tropics, where the annual cycle is more constant. The level of Lake Victoria and of some other lakes in East Africa, rises and falls with the increase and decrease of sunspots, and there is evidence of similar correlations with records of rainfall in West Africa, but this is not so conclusive. The eleven-year cycle is believed by some to account for the apparent southward migration of peoples along the southern borders of the Sahara. During the dry years of the cycle they are driven south to maintain connection with permanent water, and then, taking to a more fixed state of agriculture, they do not move north again during the wet years. If this cycle is eventually proved to be established over wide areas, it may well explain a number of variations in the biological environment; for example, there is already reason to suppose that the periodic outbreaks of locusts, which have caused

more sudden change in the African's activity than any other factor, may fit in with the scheme, and in Uganda, times of food shortage, due to failure of the short rains in the preceding years, appear to be similarly periodic.

Perhaps more important than the periodicity of general climate are the less obvious changes in the minute climate surrounding a single animal or plant. Little enough is known about this subject yet, but it is certain that the temperature and humidity surrounding a human being, for example, alter to an astonishing degree in the course of a day, and this must have great effect on his physical and mental vigour. Similarly in vegetation; work at Amani has shown how the air in a few cubic feet around a coffee bush or over a patch of earth changes to a degree which would never be imagined from the study of meteorological instruments in screened cases.

Passing to the changes in water-supply due to man's intervention, the environment in many arid parts is being altered to an extent which must influence human customs and social behaviour; for example, in the northern Emirates of Nigeria the discovery of a water table at one hundred to one hundred and fifty feet below the surface has led to the boring of numerous wells, so that areas of pasturage which were formerly available only during wet seasons can now be centres of human activity throughout the year. In Tanganyika, similar activity will soon lead to the settlement of peoples in areas of pasturage, which formerly were given over to tsetse fly. Such changes influence also the original habitations of the people involved, because the old pastures, which are to-day being impoverished by overstocking, can be allowed to rest during the all-important dry season, and may therefore return to their original value. The general result of such activity is to cause the settlement of wandering peoples on definite areas of land, a change which is a principal object of most of those responsible for agriculture in Africa.

The soils are determined by the structure of the land and underlying rocks, the water-supply, especially rainfall, and also by vegetation. The soil-vegetation unit as a controlling factor in environment is only now being recognized by scientists, but it is significant that the Africans themselves still know more about it than we, for

every cultivator bases his selection of plots for different crops on recognized associations between certain plants and certain types of soil. The deterioration and erosion of soil is perhaps the best example of any to show the rapidity of environmental change. This likewise has been recognized by African farmers for centuries, and on it have been built up the complicated systems of shifting cultivation which so admirably suit the soils and climate, provided the area of land is sufficiently large. There are many examples of individual tribes which have apparently evolved methods of avoiding soil erosion which could hardly be bettered by science. Thus the primitive pagan peoples of the Bauchi plateau in Nigeria pick the stones from their millet fields and arrange them in rows along the contours, with the result that in a few seasons the annual soil-wash leads to a definite terracing of the land. Furrowing along the contours and mound-cultivation in wet climates are likewise admirably suited to special conditions.

Before enlarging on agriculture the vegetation must be considered. This is directly dependent on the factors already discussed. The changes which constantly take place are dependent on, and themselves cause changes in, rainfall and water-supply. Perhaps man himself is the principal agent in these changes; for example, he fells an area of evergreen forest to cultivate a garden, to establish a cocoa plantation or to obtain timber. He burns hundreds of square miles of savannah for the sake of hunting honey, or of grassland to stimulate the young nutritious shoots and to kill the carriers of animal disease; and he may ruin pasture by too concentrated grazing on the part of his stock. After any of these drastic actions the natural balance is, of course, upset, and a series of changes in vegetation and soil set in which, if left to go their own way, would eventually lead on to the original type of vegetation by a succession of plant associations leading to the climax. But more usually a continual or intermittent interference on man's part prevents the natural succession, so that an entirely new type of vegetation becomes established; for example, in Uganda the huge areas of elephant-grass were once closed forest.

The effect of natural vegetation and particularly forests on water-supply is an aspect of the changing environment about which very little is yet known. It is recognized, though it is diffi-

cult to prove, that forests slow up the run-off of waters, thereby making streams run perennially instead of intermittently, and consequently their destruction, especially on watersheds and high ground, means that water is available in the soil for shorter periods. It is generally assumed also that a single stand of trees, such as a cocoa plantation, is less effective than the natural mixed forest in holding up the run-off. In the forest belt of West Africa there are many cases of destruction for the purposes of establishing plantations which have led to a very great reduction of forests during the past twenty-five years. In the Gold Coast, for example, it has been estimated that, if the recent rate of cutting were to go on unchecked, there would be no closed forest left in another fifty years. The forest question is so involved with meteorological conditions, that the number of balancing factors is legion. Some people hold that forest actually increases the rainfall directly, others that its destruction causes rain to be precipitated in occasional heavy storms rather than in frequent gentle falls. Again, in certain areas the destruction of forest in one place may affect the climate of another region far removed; for example, in the Guinea lands, where the rainfall of the dry regions bordering the Sahara is dependent on the local monsoon from the Atlantic Ocean, which passes over the belt of high forest, it is supposed by some that destruction of the high forest will cause a reduction of rainfall in the dry regions of the north.

Opposed to these changes, most of which lead to lessened water-supply, forestry departments are attempting to maintain the original environment by the reservation of forest areas, and in some cases by direct planting. Here again, another question arises in that many exotic trees which are used in afforestation grow more rapidly and have a higher transpiration rate than the original indigenous trees. Accordingly it is supposed that the new forests, in parts of South Africa for example, actually reduce rather than increase the soil moisture. The amount of timber available for building and firewood clearly depends upon the area of forests, and the conditions imposed upon its use. It is a striking fact that at present there are practically no data as to the amount of timber required by native populations.

Wild animals are important factors in the environment, as food,

as destroyers of crops stock and even man himself, and in providing reservoirs for diseases such as rinderpest, trypanosomiasis and east coast fever, which may endanger domestic animals. It appears that the western parts of Africa have never supported wild game in numbers comparable with the east, but for a century or more this difference has been accentuated by the extensive use of firearms in West Africa. In general throughout Africa there has been a pronounced change in the last fifty years, in that the number of wild beasts has been reduced to a striking degree, the extreme being reached in those parts where anti-game campaigns are being waged with a view to ridding the country of tsetse flies, as in Southern Rhodesia. But there are certain exceptional areas, mainly the game reserves, where the African now lives under the restraint of game ordinances, so that the number of animals surrounding his farms and stock ranches is greater now than ever before. On the whole it appears that the development of game organizations has led the African to rely for the protection of his possessions more on the local game scout armed with an elephant rifle than on his own prowess.

The water environment, sea, lakes, and rivers, as a source of food for man, is likewise undergoing change. Sometimes the stocks of fish have been reduced by the introduction of European methods of fishing, or by commercial exploitation; in certain cases exotic fish have been introduced to African lakes and streams; but on the whole the fishery resources of the continent present a considerable undeveloped opportunity for human activity.

In the subject of cultivation we start with conditions in which man has become closely adapted to the environment of climate soil and vegetation, having evolved systems of shifting cultivation. Two kinds can be distinguished; one in which the people live permanently in the same place and cultivate surrounding plots in rotation, and the other in which the village sites are changed at frequent intervals. The former is characteristic of comparatively dense populations, and the latter of forest areas where there is no limit to the amount of land. The really important factor is the proportion of resting years to cropping years necessary for the soil to regain its original fertility, a proportion which varies throughout the continent from about 1/3 up to 1/infinity. The proportion

has been altered over large areas by too-frequent cultivation, partly by direct pressure of population, but mostly by the introduction of cash crops, which necessitate the cultivation of much larger areas. An extreme case is the Owerri Province of Southern Nigeria, where the agricultural population is probably denser than anywhere else in the continent, between 300 and 400 per square mile. In this area the resting period which the soil actually receives has been reduced almost to nil, with the result that the resting period which would be required to restore its original fertility is very long indeed. The reduction of soil fertility which results from these factors is well demonstrated in Senegal, which has been given over to the production of groundnuts. Here three belts can be defined in terms of rainfall conditions, one in the dry land to the north, the second stretching east in the latitude of Dakar, and the third in the damper country surrounding the Gambia River. When groundnut production first started the northern belt was found the most suitable and population concentrated there. Soon the soil deteriorated, and to-day practically all the export comes from the middle and southern belts, whereas in a few years' time it is feared that the middle belt will become much less profitable. This series of events has naturally helped in the southern migration of people referred to above.

Against these factors agricultural workers are attempting everywhere to change the crop/fallow proportion in the other direction by establishing systems of fixed cultivation, building upon that type of shifting cultivation where the population remains in the same place. The methods which are being introduced involve the rotation of crops, mixed cropping, green manuring, composting, and especially mixed farming, all of these being designed to put fertility back into the soil as fast as it is drawn out by crops. As an example of the adaptability of such systems when under pressure of population, we may refer to Ukara Island in Lake Victoria, where a genuine system of mixed farming, of the type which agricultural experts are attempting to popularize in both East and West Africa by various kinds of education, has apparently been spontaneously evolved.

Many of the environmental changes considered above affect man indirectly through his stock, and therefore some of the changes

in stock husbandry must be reviewed. Since the arrival of the European, the number of large and small stock has increased beyond measure. This has naturally reflected upon the condition of the grazing and thereby has formed a vicious circle by removing the vegetation and stimulating soil erosion in a way closely comparable with the effects of shifting cultivation. In an effort to replace the superfluous numbers of native stock by fewer animals of better quality, European science is causing another marked change in the African environment. The experiments have not extended widely in purely native areas, but they will make themselves felt in the next quarter of a century. Efforts are directed primarily to producing better animals for the dual purpose of milk production and draught, and have been closely connected with attempts to introduce mixed farming as an alternative to shifting cultivation.

Meanwhile animal diseases, which were formerly important agents in keeping down the numbers of domestic animals, have been reduced by the introduction of European science. Rinderpest, for example, was introduced to Africa in the latter half of last century, and was spread throughout most of the continent partly by the migrations of wild animals, many of which, particularly buffalo, are very susceptible to the disease. Intensive study, stimulated by its occurrence in epizootic form, has led to the perfecting of vaccination. The results in changing the environment for stock may be gauged from the fact that to-day almost every animal in the Fulani herds of Northern Nigeria is inoculated against rinderpest before it is a year old. In a similar way east coast fever, a tick-borne disease which is indigenous throughout eastern and southern Africa is being brought under control by the compulsory dipping of animals at regular intervals to destroy the ticks. This and related diseases provide an interesting example of a measure of control which is employed by native pastoralists, even though they do not fully understand the part played by ticks: the habit of burning pastures during the dry season not only stimulates the growth of young nutritious grass, but also destroys the ticks which find their home in the old grass. This custom, in so far as it contributes to the increase of the herds, plays its part in the vicious circle of overgrazing and soil erosion, and hence is a cause of much

anxiety to those who are responsible for conserving the pastures as well as destroying the ticks.

Another important source of animal disease is the tsetse fly. It is well known that the so-called tsetse belt covers the greater part of tropical Africa between a line from the Senegal River to Italian Somaliland and another in the south from the coast of Angola to Mozambique. A large part of this area is dominated by one or other of the twenty species of fly rather than by man. The numerous fly-fronts are continually subject to oscillations, many of them recurring annually when in the dry season high temperatures drive the fly to take refuge in the narrow bands of vegetation bordering the watercourses. But the great changes in fly distribution which are now hoped for depend primarily on human endeavour. In Tanganyika, for example, the clearing by organized native labour of the bush which harbours the fly has enabled 5,000 natives to return to land in one chieftainship from which it had previously driven them. Again, in Southern Rhodesia, the destruction of the wild animals on which the fly feeds has resulted in freeing considerable areas from trypanosomiasis.

Periodic locust invasions injure man through the destruction of his crops. Here too, advances in studies which are slowly leading to an understanding of locust ecology may be expected before many years pass, to prevent or at least reduce these visitations, and thereby render the African environment far more favourable to man.

In connection with the numerous other pests of agriculture, it is noteworthy that the change from extensive to intensive land utilization tends to make the environment more favourable to pests. The distribution of an insect or fungal parasite must clearly be easier where the plant on which it lives is cultivated as a single crop over a large area, than where a number of plants are grown together, as in the native system, in small fields which may be separated by forest areas. A parasite, which in these circumstances causes practically no damage, may become a pest of first-rate importance where modern methods favour its rapid spread. Another factor has been the introduction of domesticated plants from one territory to another, and from other continents. These often bring their own parasites with them, which find suitable hosts in indigenous crops. Thus the mosaic disease of cassava, which is growing in importance

throughout West Africa, and in parts of East Africa, is supposed to have been introduced in comparatively recent years. Certainly its distribution around the Guinea Gulf is now extending inland from a number of foci near the coast.

The influence of these factors on the food supply is one of the most obvious ways in which they may affect human welfare. The social significance of seasonal changes in the quantity of food available has recently been studied by anthropologists as part of the analyses of the native agricultural practice and economic organization. Variation in quality of food is also important, since different items in the dietary become available at different seasons, often for only very short periods. These variations are particularly significant in the case of African peoples whose staple diet is generally so monotonous that the curtailment of any of the subsidiary foods, small though the proportion of the diet that they represent may be, may result in a complete lack of animal proteins or other essentials, and so give rise to malnutrition and disease. Therefore, on the variation of food supply depends to some extent the African's resistance to disease, and hence the relation to the last of our environmental categories.

The internal environment of the human organism above all others is altered by its biological content, and is capable of adaptation thereto, as shown particularly well by immunity or partial immunity to diseases. Some of the changes involved may be illustrated by reference to three important diseases: malaria, yellow fever, and sleeping sickness. Nearly every African is infected with malaria before he is three years old, and subsequently develops at least a partial immunity, because his body at that age is capable of much greater adaptation than later on. In many parts of Africa measures are now being taken to stamp out malaria, particularly in townships, and a section of medical opinion favours the extension of these measures into rural areas wherever possible. Such action would probably reduce the high infant mortality of many parts of Africa. But the adult native, who had not become inoculated in childhood, would be certain to meet the disease at a later stage in life when his adaptability is not so great.

Yellow fever also is often contracted by Africans at an early age; the patient either dies or attains immunity for life. Recent work

has shown that this disease is not restricted to the endemic centres on the west coast, but extends in a dormant form throughout large tracts of Africa as far east as Uganda and the Sudan. It has been pointed out recently by medical authorities that these potential centres offer opportunities, through the agency of air transport, for the spread of the disease to huge populations not only in eastern and southern Africa but even in a wider area.

Slower transport by road, rail, and ship can create similar problems. For example, sleeping sickness is caused by small organisms in the blood, of which there are probably many local strains. A population accustomed to one strain and having developed a certain degree of immunity may wander into the realm of another strain, and thereby suffer from a violent epidemic. This has probably occurred in many parts of Nigeria, where the environmental conditions both inside and outside man differ so widely from north to south, and where it is believed that sleeping sickness has increased during the last quarter of a century. In estimating the increase or decrease of disease, it must be remembered that in the absence of comparable statistics, figures of incidence depend in a large degree on the activity of doctors.

In this sketch of the changes now proceeding in the African environment, the principle of the cinematograph has been adopted rather than that of the snapshot. Although this volume as a whole attempts to depict a cross-section of present-day scientific activity, the cross-section is only made possible by imagining the process of change to be temporarily suspended for examination. The picture really presented by Africa is one of movement, all branches of physical, biological and human activity reacting on each other, to produce what biologists would refer to as an ecological complex.

LAND PLANNING

Every branch of human activity, including cultivation, grazing, forestry, game preservation, mining, and administration, involves the utilization of land, and the claims of the various activities often come into conflict. An analysis of the existing utilization and potentiality of land is therefore of great significance. The policies which have been followed in defining rights to land are discussed in *An*

African Survey. Data from various areas have been made available through surveys of topography, geology, soils, water-supply, forests, cultivation, stock, etc. Such surveys are merely the raw material on which a planned system of land utilization could be based.

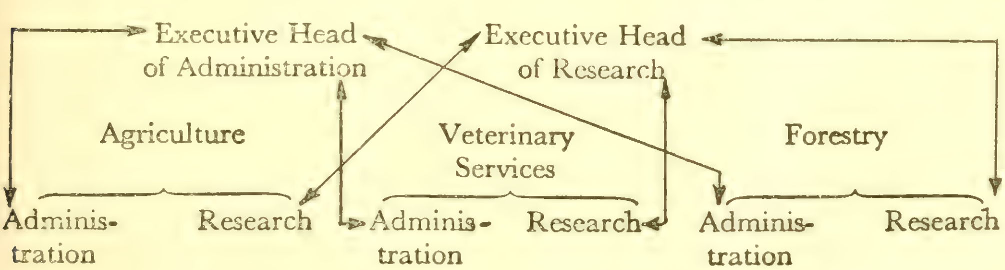
The kind of data which throw most light on the problems of land utilization vary with the state of development of different territories. In every case a topographical survey is essential: it is also widely held that soil and ecological surveys are indispensable. Where agriculture is highly developed as in most parts of Uganda, an ecological survey in the usual sense would be mainly of academic interest. In such areas a general agricultural survey, based on the knowledge of field officers already at work, should give all relevant information, especially when combined, as it is now in Uganda, with surveys of water-supplies, health conditions, etc. The same might be said of the southern parts of Nyasaland, where a full agricultural survey, which will be of fundamental importance for later developments, is in progress. Again, the agricultural officers in Tanganyika, in the course of their ordinary duties, have accumulated material for agricultural surveys and such data have been published for one or two districts. The results can be combined with those of the topographic and geological surveys already in progress, the soil survey which is coming from Amani, and the ecological data gathered by the Tsetse Research Department and by studies of livestock and medical subjects. Such material would give an adequate basis for a policy of land utilization, with regard, for example, to such questions as the effect on the soil of a rapid extension of commercial cultivation.

In the vast areas of Africa, where population is scanty and the potentialities of the land are not yet known, as exemplified by most of Northern Rhodesia and the Southern Sudan, the problems of land utilization are still more important. Here it is important to point out that in many parts of Africa, soil and vegetation are being altered at so great a rate that there is danger of many areas being soon rendered uninhabitable for man. Surveys of soil erosion and studies of vegetation, with a view to its preservation, are therefore of the utmost significance and will be considered in some detail in later chapters.

CO-ORDINATION AND CENTRALIZATION OF RESEARCH

For the very reason that the greater part of Africa is still in the early stages of development, the continent may offer the most fruitful field in history for experiment concerning the place of expert scientific knowledge in land planning. The formulation of any such policy must depend upon close co-operation between different territories and between the technical departments in each territory who are concerned in its application, in particular the agricultural, veterinary, and forestry services. In India and the British Dominions this need is met by the combination of these departments under one executive head.

The organization of the research work on which policy must be based is also a question of major importance. Although scientists in general are coming to agree that no valid distinction can be drawn between pure and applied science, there are many problems, often those the solution of which will prove to have most valuable practical applications, which require detailed concentration for considerable periods. Such concentration is not possible if the duty of the research worker is conceived as being confined to the solution of problems of immediate policy. Accordingly there is much to be said for the system applied in the Anglo-Egyptian Sudan, of separating research organization from the executive work of the technical departments and placing it under a separate Director of Research. Such a Director would logically have the same standing as the executive head referred to above. In a Crown Colony it would be desirable that both should have seats on the Executive Council. Taking the three subjects of Agriculture, Veterinary Services, and Forestry, such an organization could be represented as follows:



Despite the close connection of the medical and sanitary services with those discussed, it would hardly be practicable to place them under this unified control; but here again the detachment of the long-term research worker from preoccupation with administrative detail would have a beneficial effect. It is interesting, therefore, to note that the appointment of a Director of Medical Research for the block of British East African territories has been suggested. This might have the double effect of enabling some kinds of research to proceed uninterrupted, and of promoting closer co-operation between the several territories concerned.

The relations between Entomology and the other studies mentioned are rather complex. Although insects are of the utmost importance as disseminators both of animal and human disease, the same insect is rarely responsible for disease both in men and animals. Accordingly there seems no great advantage to be gained by centralizing entomological research as a whole. In the case of the tsetse fly the position is very different, and the question may be raised whether all studies on trypanosomiasis of humans and animals should not be centralized instead of dispersed between a number of departments as at present.

The development in recent years of periodic conferences for the discussion of research on a wide basis has produced a great improvement in the interchange of information and co-ordination of results. Conferences of officers in the different services, surveys, geology, forestry, agriculture, and medicine, are held from time to time, and in British East Africa the meetings arranged by the Conference of East African Governors have become a regular feature of scientific life. The time may perhaps come when similar gatherings will be held in West Africa. International pan-African health conferences have already been held, and it is to be hoped that similar conferences, dealing with other sciences, such as are organized for the Pacific and America, will follow in due course.

FINANCE AND AGENCIES FOR RESEARCH

Any discussion of the centralization of research at once raises the question of finance. At present it is practically all financed from current revenue and therefore the annual votes are bound to

fluctuate with economic conditions. Since the planning of research depends above all else on the guarantee of continued support for a sequence of years, it has been urged that all research of the long-range type should be financed from special funds raised by loan. The disadvantages peculiar to land survey work are discussed in some detail in Chapter II, but the same arguments apply to many other branches of study. In medicine for example, a research fund, raised by the group of East African territories and allocated by the Director of Research mentioned above, would enable work to be carried out without the haste which reduces the value of much research, and without the worry entailed to the workers from the possibility that they will not be given an opportunity of attaining their objects. In this particular case there would be no need to expend money on the erection of special buildings, because the existing institutes should provide ample accommodation and facilities, so that the whole fund could be used to provide salaries and equipment for workers. By such means, which are similar to those adopted in India in connection with the Indian Medical Research Fund, the most economical use could be made of any money available for fundamental studies, while routine work and small pieces of research which arise locally would be carried on by the local staff of the various laboratories.

In surveying the agencies which exist for research, as outlined in the following chapters, there are striking and instructive differences in the systems adopted by the British, French, and Belgian administration. The British territories have permanent research officers as members of the departments of agriculture, medicine, etc. The number of such officers is designed to be more than sufficient for the routine work, so that some, at least, have time for research. In the Belgian, and to a less extent the French systems, fewer permanent scientific officers are employed in Africa, but an extensive organization exists whereby special surveys or scientific studies are undertaken in Africa by missions sent out from Europe, often arranged with the collaboration of universities. Both the British and Belgian systems have their own advantages: the former leads to the establishment of a regular cadre of workers who look upon Africa as the home of their work, while the latter retains closer touch with the centres of science in Europe.

Clearly a combination of both methods would be the ideal and one which should not be hard to achieve. In the case of Great Britain there seems to be scope for more co-operation on the part of the universities. A few university departments have contributed to the study of African problems, such as those to which certain of the Imperial Agricultural Bureaux are attached, the forestry department at Oxford and the anthropological department of the London School of Economics. But with these exceptions, it cannot be said that the great universities are playing an important part in the modern scientific development of Africa, except in providing training for some of the men who are subsequently absorbed into the services. From time to time expeditions go into the field under the auspices of universities or scientific societies to undertake special inquiries, but nearly always the financing of these depends on individual initiative on the part of their members. It may in the future be found possible to introduce post-graduate students and others in search of subjects for research to matters related to African problems. There are already a number of first-class centres of research suitable for visiting workers, and at nearly all of these are specified problems of wide application, of the type that the local staff have no time or opportunity to undertake. If the universities were to assist in the solution of such problems the advantages would be many, both to the African territories in obtaining for short periods keen men possessing the latest knowledge in their special subjects, and to the workers themselves in the opportunity for widening their experience and in carrying out the type of research which may become widely known. Difficulties would arise in financing these schemes, but it might be possible to pool contributions from various sources in such a way as to encourage a method of work by which more than one partner would benefit.

Another instructive contrast between the British and French colonies is that in the former there sometimes appears to be a certain lack of economy in apportioning the work to be carried out by officers who have had a high scientific training. Especially perhaps in East Africa, there are many first-class agricultural officers, trained at Cambridge and Trinidad, among whose work there figures prominently the kind of routine field duties which could be discharged at least as efficiently by men less highly trained. It

is true that the employment of first-class officers in the agricultural departments was responsible for the great progress of cotton cultivation in Uganda, but whether the same agency is required elsewhere remains open to question. It is also true that there are difficulties in the division of an agricultural department into two sections, the more highly trained men employed in research and the control of pests, and the less highly trained performing routine field duties only, because scientific work is an integral part of the department alike in the field and laboratory. Nevertheless, these considerations point to one of the greatest needs of Africa to-day, that of trained subordinate staff. This lack is felt not only in agriculture, but in every other branch of activity, and great efforts are being made in many parts of the continent to fill the gap by the higher education of African natives.

WASTE OF RESEARCH

The efforts of scientists throughout Africa result in the publication each year of a great quantity of material, mainly in official documents such as annual departmental reports, bulletins, pamphlets, and occasional papers. It is worth considering for a moment how many of these results eventually reach the scientists, outside the territory concerned, who are working along similar lines or on kindred subjects. To the busy scientist whose work includes the perusal of many hundred books and papers generally presented in a more or less uniform manner so that he can extract the contents with little trouble, the average annual report is somewhat difficult to handle. In their present form, they are not designed primarily to give information to the scientific expert: they are reports on departmental activities rather than on the progress of scientific research as such. In some cases the results obtained by individual workers are rewritten as scientific papers and submitted for publication to scientific societies or journals, but this represents an additional labour, which many officers are unwilling to undertake.

It might be possible to adopt an agreed scheme for the presentation of reports which would include a common format, the separation of scientific fact from administrative detail, a standardization

of form for statistical tables and some means of referring to the contents. This question is discussed in Chapter III with reference to the publication of geological surveys, which are by no means more complicated than those of other departments.

Another serious source of waste in scientific work comes from the fact that a great deal of data which is not published, and indeed in its raw form is quite unsuitable for publication, becomes lost. In the course of ordinary duties officers of medical, agricultural, administrative, and other departments, record a mass of detail about the country and its inhabitants. Some officers have collected notes of great scientific value about the people, their customs, food, diseases, etc. The bulk of these notes are kept in the files of district offices, where they are not easily unearthed and may never be remembered when at a later date some investigator wishes to make enquiries on similar lines. In these days, when research on African problems is coming to depend more and more on organized co-operation, all such data are of value and could be saved for posterity, without any large organization or heavy expense, if in each territory there were a clearing-house to which all such information were sent and classified, probably on the basis of the administrative district from which it came. From time to time the material collected would be worked through and sifted, and perhaps written up into suitable publications.

A further source of waste relates to the exchange of information and bears upon interterritorial co-operation. It so often happens that work is duplicated in different parts of Africa, or that sets of data are obtained which might be of the utmost comparative value, only each piece of work is done in ignorance of the other and by slightly different methods, so that comparison is difficult. Furthermore there are many papers published which are of importance to African workers, but are never heard of except by casual reference in some book or article published long afterwards. The admirable services of the Imperial Agricultural Bureaux and of the Bureau of Tropical Diseases have gone far to override these difficulties by publishing abstracts and bibliographies and enabling workers in Africa to obtain copies of articles of interest; but these bureaux deal only with their own special subjects, and there still seems room for some organization interested in African develop-

ment to assist in this interchange of publications and information on more general lines.

Any subject concerning Africa has really to be studied as a world subject and not merely in regard to its implications in that continent. Thus the mapping of Africa's surface must be designed to fit into the geodetic triangulation of the world; anyone working on sleeping sickness needs to be familiar with literature on biting-flies and their habits in all parts of the world, with studies on plant succession, etc. It follows, therefore, that such an organization as that suggested above would be most useful in putting the inquirers into touch with the right authorities in each subject, and in knowing who is working in Africa on all branches.

CONCLUSION

There has been a great awakening of interest in the part that science can play in African affairs. This is shown by the formation in recent years of organizations such as the *Association Colonies-Sciences* in Paris, the *Institut Royal Colonial Belge* in Brussels, the Commission of Scientific Research for the Portuguese colonies, established in 1935, and a similar organization recently formed in Rome for the increased Italian possessions. Then the societies and universities of South Africa, especially the Royal Society of South Africa and the South African Association for the Advancement of Science, have had an influence which extends far beyond the frontiers of the Union. In England the Royal African Society and the International Institute of African Languages and Cultures have done valuable work, and in most territories societies have sprung into being, many of which publish their own journals containing articles of much value.

In spite of all such signs of interest, however, and in spite of the admirable hands in which, as a general rule, the direction of science lies, it could not be claimed that African development has so far been greatly influenced by the results of scientific research. In a continent which has been developed almost wholly in the twentieth century, there might have been more room than elsewhere for such influence, but this has not been the case; economic development has taken the lead and often chooses the wrong turn-

ing. Science follows, but the pace is laboured, and falling behind she is neglected. Often she has to follow along the wrong path for some distance before beckoning development back to the direct way. Roads and rails have been built before there were accurate maps on which to mark them; crops have been introduced and grown under all kinds of conditions, regardless of the suitability of the soil; inter-tribal warfare has been stopped; we seek to increase the native population, improve their standard of living, and economic status, and native stock multiplies to such an extent that the earth is denuded of vegetation and the soil may be washed away to sea by the next storm. A development based on a real understanding of Africa's potentialities has hardly yet begun, and will be impossible until the necessity of scientific knowledge is recognized.

CHAPTER II

SURVEYS AND MAPS

INTRODUCTION

KNOWLEDGE of the size, shape and characteristics of a territory, such as is obtained by survey and mapping, is an essential preliminary to further study. Of primary importance is the construction of a correct framework on which to base mapping of every kind in order that inconsistencies may be avoided. Such a framework may be compared with the foundation of a house. The three stages of survey, from the foundation to the smallest detail of the finished building, are designated as geodetic, topographical and cadastral, terms which are used throughout this chapter in the senses defined below.[1]

Since the requisite accuracy can now be attained with small light theodolites, geodetic triangulation is much less costly than it used to be. Base lines also have ceased to involve the large expenditure of time and labour that they used to entail; they are now measured swiftly and easily by a small party of men. Conspicuous examples of the advantages to be gained are provided by

[1] *Geodetic Survey* is concerned with the positions of certain series of points, that is to say their latitudes and longitudes (or their co-ordinates on any other system) and their heights. These points and the lines joining them constitute the framework. They are fixed by means of baselines and triangulation of 1st, 2nd or 3rd order, or a framework by means of precise traverse when the terrain is unsuitable for triangulation, as in country covered by heavy forest. Geodetic survey provides the foundation of all maps, whatever their scales.

Topographical Survey is concerned with features. It shows whatever is visible on the ground, as for instance roads, railways and houses, and it will also probably show major boundaries such as those separating different territories or administrative divisions of a country. Topographical maps may either be 'small scale' which includes scales from 1:2,000,000 ($31\frac{1}{2}$ miles to 1 inch) to 1:250,000 (about 4 miles to 1 inch), or 'Large scale' ranging from 1:125,000 (about 2 miles to 1 inch) to 1:25,000 (about 1 mile to $2\frac{1}{2}$ inches).

Cadastral Survey is concerned with property boundaries which are often invisible on the ground, and is frequently carried out with a view to the assessment of taxation. Cadastral maps are seldom on scales smaller than 1:5,000.

India and South Africa (see below). On the other hand, there are instances where the lack of adequate topographical data has led to unnecessary expenditure. In the Gold Coast, for example, the railway from Sekondi to Kumasi, which was constructed at the end of the last century without full topographical knowledge, had to be realigned in 1922 and subsequent years at a cost of some £2,000,000. In Kenya, Uganda, and the Rhodesias, some railways have had to be realigned, while in others the cost of operation is unduly high. Numerous instances could be selected where roads have had to be realigned at heavy expense for the same reasons.

The case for the comparatively small expenditure on fundamental surveys was well put in 1933 by Brigadier Winterbotham, until lately Director General of the Ordnance Survey: 'The geodetic triangulation of a country is not only the guarantee of the accuracy of surveys—it is an undertaking which cheapens as well as co-ordinates, all other surveys. It is the first step in relieving the property surveyor from a reiteration of patchwork triangulation and traverse. It sets a term to perpetual revision and recomputation. It is at once a real practical economy and a contribution to general knowledge conceded everywhere as a duty to scientific development.'

In his Presidential Address to the Geographical Section of the British Association in 1936 Brigadier Winterbotham pointed out that passages could be quoted from eminent administrators, engineers and scientists of all kinds stressing the necessity of good maps for development, and yet in many parts of Africa the maps available do not even show main roads correctly.

In this connection it is instructive to contrast the history of survey work in India and in Africa. In India a framework of major triangulation was completed early as a basis for all subsequent work. Systematic topographical and finally cadastral surveys followed. In Africa north of Southern Rhodesia, we have so far only one chain of primary triangulation, the 30th meridian, of which several stages are still incomplete. The difference is clearly attributable in part to the greater difficulties of the work in Africa with its sparse population and great areas of undeveloped country.

The topographical data which would be desirable include detail

of areas of permanent cultivation, grazing, scrub, and forest. Maps of the type of the later Indian survey 1 inch series, but elaborated along the lines of the Danish survey or the British land utilization survey, would be the ideal. As a preliminary, however, a map on a smaller scale such as 1:250,000 would serve, provided it were contoured, but even this can only be drawn with accuracy after a secondary network of triangulation is firmly based on chains of primary triangulation.

In the absence of such work, however, results of sufficient accuracy for many purposes can be attained by the method recently evolved in French West Africa of making topographical maps of an advanced reconnaissance type by means of rapid traverses. This method has been employed with advantage in the little-known areas bordering on the Sahara Desert. It is possible owing to the fact that longitude is now quite easy to obtain accurately by receiving wireless time from Greenwich; as easy, in fact, as latitude has been for the past fifty years. Therefore rapid route surveys can be accomplished with reasonable accuracy. Such route surveys made by surveyors, as they travel from place to place on triangulation or cadastral work, could contribute much valuable information for topographic purposes. The data required as a general basis for scientific and administrative work could thereby be produced quickly, the tedious geodetic work following later. This system would be particularly appropriate to areas where population is small and where great accuracy for purposes of cadastral survey is therefore not required.

Cadastral survey itself is necessary in Africa on account of conditions peculiar to undeveloped areas; it requires an accurate geodetic basis, but this fact has unfortunately tended to be disregarded in parts of the continent. In England compulsory registration of title with Crown guarantee is not universal, and even in those counties where it has been introduced, land titles rest on the topographical map only. The guarantee does not exclude the possibility of a boundary dispute between neighbours nor does it insure a landowner against loss arising from such a dispute. In short the landlord is given title to a piece of land marked on a general map but not precisely defined by boundaries of stated lengths and bearings. This system suits English con-

ditions well enough, mainly because there are relatively permanent physical features such as hedges, ditches, and fences to safeguard the rights of the owners.

In Africa farms are for the most part unfenced and only partially developed. The title of a landowner rests on a plan attached to his deeds on which are shown the beacons marking the corners of his land and the lengths and bearings of his boundaries. These lengths and bearings have been calculated by a cadastral survey based on the controlling triangulation, and the co-ordinates of the corner beacons have been mathematically computed in relation to the framework provided by that triangulation, and registered on plans in the Survey Records Office. The field notes of the original survey are also registered in that office. If the beacons are destroyed, as they often are, ownership is still safeguarded by the assurance that they can be replaced from registered data with the accuracy attained in the original survey. Such a system is essential to all security of ownership in territories such as South Africa or Kenya, and the work which it entails absorbs the entire energies of the survey staffs which the Colonies have found it possible to maintain in times of depression.

The history of land surveying in South Africa illustrates the disadvantages which ultimately result from cadastral surveys made without adequate geodetic control. This question is so important that a few quotations from authorities in South Africa are given by way of illustration.

The Government of the Cape Colony in 1878 appointed a Commission 'to make a full investigation into and report upon a more adequate means of testing the accuracy of land surveys in the Colony'. The principal recommendation (No. XVIII) was that a secondary triangulation based upon the geodetic coastal chains of Maclear and Bailey be extended over the Colony (1878). A year later Sir David Gill, in submitting his famous scheme for the geodetic survey of South Africa to the High Commissioner, objected to this uncontrolled triangulation. He insisted that a scientific system of triangulation 'is much more economical both in execution and reduction than that recommended in Section XVIII of the report; and coupled with secondary triangulation can be made to afford any desired accuracy' (1880).

Gill's scheme was accepted by the Government, and in 1905 the geodetic framework of the Union of South Africa was completed. Unfortunately very little was done to fill in the framework with primary and secondary triangulation, neither was legislative effect given to the recommendations of the 1878 Commission. Consequently the Government found it necessary to appoint a second Commission in 1921 to enquire into the unsatisfactory state of survey affairs in the Union.

This Commission opened its report with the following statement: 'The Commission cannot state too emphatically that the present system of land surveying is unsound, inefficient, expensive, and without finality'; and (in paragraph II, 5) 'the system involves the community at the present time in an unnecessary expenditure on farm surveys alone of, we estimate, approximately £50,000 a year'.

The importance of the geodetic survey to property surveys is expressed by the Commission (in paragraph III, 1) as follows: 'The history of the survey of a country follows the same course in every land. All governments experience the same difficulties in the first settlement; security of title and other advantages cannot be guaranteed because the country is not properly surveyed; on the other hand, the proper survey cannot be carried out because the land value does not justify the necessary expense; hence we find in every country initially the system of isolated surveys. As the country develops and the land becomes more valuable, the system of survey leads to litigation about boundaries, to increased interest on money advanced on mortgage of land, and renders the civil and military administration of the country expensive and unsatisfactory. In the end the government of the country is compelled to establish a scientific system in order that development be not retarded. Legislatures, whose members are mostly laymen in survey matters, have everywhere shown a disinclination to face the facts of the survey situation, because the substitution of a scientific system entails the scrapping of the work of generations. The longer the scrapping is delayed the greater is the waste. In South Africa each surveyor engaged upon a survey measures his own base, and resultant therefrom, millions of bases have been measured, all of varying standard; this is one of the main causes of error in survey

work, and if the present system is continued, then further millions of bases will have to be measured and scrapped when the time comes for all surveys to be made on one standard base—namely the trigonometrical triangulation of the country.'

It is important to note that the funds for the geodetic survey of the Union, upon which about half a million pounds have been expended, have been obtained mainly on the grounds that, ultimately, it will provide a final solution to the cadastral problem (Grobler 1927). Furthermore, Sir David Gill succeeded in persuading the Government of Southern Rhodesia to undertake the arc of meridian through its territory solely on the ground that it would enable the Government to establish a system of sound title to land. In 1928 the mover of a motion in the Legislative Assembly of Southern Rhodesia for continuing the trigonometrical survey in that country, stressed its importance in both cadastral and topographical surveys (Fletcher 1928).

At a conference of Survey Officers of the Empire in 1936, Mr. Whittingdale, Director of the Trigonometrical Survey of South Africa, spoke in emphatic terms of the immense saving that had accrued to that country from the geodetic survey. He drew particular attention to the importance of such work even where the land traversed appeared to be valueless. The fact that the geodetic survey of the Union preceded the discovery of many important mineral deposits has saved the country enormous sums.

The degree of precision aimed at and obtained in the successive orders of triangulation in the geodetic survey of Southern Africa would not be necessary for the control of a topographical survey alone. A country with a valuable mining industry, which is extending every year, and sometimes in the most unexpected areas, cannot afford to be careless of inches in its land surveys.

ORGANIZATION

BRITISH

In the *Union of South Africa* each of the four provinces, the Cape, Natal, Transvaal, and the Orange Free State, has its own Survey Department under a Surveyor-general, which deals solely with property survey. All other surveys are carried out by the Union Trigonometrical Survey, established by the Land Survey Act,

which provides that the Director shall conduct all geodetic, topographical, level and tide surveys and geophysical operations in the Union. The Survey Board, consisting of the four Surveyors-general and the Director of Trigonometrical Surveys, has advisory functions in matters of general policy, the Secretary for Lands being the executive officer.

It is sometimes suggested that, as provided in the Survey Act, a Director-general of Surveys should be appointed to take general and executive control of the whole survey organization in the Union. Nevertheless, uniformity of practice and policy is well maintained under the present system. The greatest drawback to progress does not lie in the method of control, but in the system whereby all survey work is undertaken by private practitioners. The topographical survey is an exception to this rule and the appointment of a salaried staff for carrying out trigonometrical survey operations, other than triangulation, is under consideration.

An excellent framework of geodetic chains was established by Sir David Gill and Sir William Morris, R.E., in the years 1883 to 1906. Since 1919 the primary and secondary triangulation has been extended and based upon this geodetic framework over most of the Union. About £20,000 is now being expended annually in completing this triangulation and also a tertiary triangulation over the more valuable and highly developed areas of the country. The principal triangulation is admittedly efficient and provides a permanent basis for surveys of all kinds, and the cadastral system meets all technical and legal requirements to ensure security of title.

The topographical survey has not been pursued to a comparable extent: of the topographical maps still in use the majority were made after the South African War by military surveyors under the direction of the War Office. A comprehensive scheme for topography has now been approved and a start has been made.

In *Southern Rhodesia* the reorganization of departments in 1931 brought surveys together with meteorology, agriculture, veterinary work, etc., under the Department of Agriculture and Lands. Trigonometric survey has followed the example set by the Union and several of the chains of triangulation are direct continuations of those to the south. Like other parts of Africa, Southern Rhodesia

has its own problems of cadastral survey which absorb a considerable part of the survey staff's effort.

Each of the *British Colonies, Protectorates and Mandated areas* (except the Gambia) has a survey department whose duties are (1) triangulation and topographical mapping: (2) cadastral surveying, including the delineation of property boundaries and town-planning. Expert advice on the correlation and the direction of survey policy is tendered by the Colonial Survey Committee and also by the War Office.

With increased settlement and competition for land there is a tendency for property and settlement surveys to come into prominence to the detriment of topographical work. Topographical maps, where they exist at all, are seriously out of date for many areas, and very little work in geodetic triangulation is being done. Most authorities at home recommend the development of triangulation and topographical mapping in the colonies, and with this in view the representation on the Colonial Survey Committee, of expert opinion on geodesy, has recently been increased.

In view of the limited resources of the Colonial Governments it seems probable that the extension of such work must depend on the allocation by the Imperial Government of special funds for the purpose. Moreover, some kind of inter-colonial organization would be desirable. It might be possible to form a single geodetic survey department for British Africa. Some experts would go so far as to suggest an Imperial Geodetic Department similar to the Hydrographic Department of the Admiralty, but others argue that the control of African surveys would be best exercised from some point in Africa. The case for centralized control was put forward by Brigadier Macleod (1936) at the Conference of Empire Survey Officers in 1935, and discussed by delegates from the Union of South Africa, Southern Rhodesia and most of the colonies. Various difficulties were put forward, but all delegates were agreed as to the desirability of central co-ordination of geodetic surveys, and all were willing to be given a lead by the Imperial Government. The Royal Society, at the request of the National Committee for Geodesy and Geophysics, has addressed a memorandum to the Imperial Government urging it to undertake responsibility for geodetic work in the Empire. Whether or not the ideal can be attained, it seems

clear that central departments could be created for groups of territories with an organization analogous to that of the Union. The Surveyors-general of the different territories and the Director of the central department would form the directing board. Under such an arrangement plans of work could be co-ordinated, and consultation between the colonial and home authorities could be arranged through the Colonial Survey Committee, in connection with the periodic conference of Empire Survey Officers.

FRENCH

The fact that surveys in French territories are directed by the *Service Géographique de l'Armée* gives a military character to the work done. In addition, organizations exist in Africa which are more or less independent of the department in Paris. The details are given by M. de Martonne (1928 and 1935). The Service Géographique in French West Africa will serve as an example. The Director, with an office in Dakar, is responsible only to the Governor-general and has a staff of seven specialist surveyors and nine sous-officiers, of whom half work on geodetic triangulation and half on topography. In addition there are officers in charge of the drawing, computing and printing offices where most of the work is carried out by African subordinate staff. The French do not stress the importance of triangulation very much, and the only area where this is complete is the mountainous region of French Guinea. Most of the other country is so flat that triangulation is difficult and the subsequent surveys depend on points fixed astronomically to one-hundredth of a second.

Topographic maps are constructed from route surveys, as has been mentioned on page 27. This method is used in the desert areas such as Mauritania, the Sudan and Niger Colonies, where all survey is carried out by officers of the Camel Corps who are responsible to the Service Géographique de l'Armée in Paris. By this means it is claimed that practically every large rock in the Sahara is now fixed in position. Cadastral survey is carried out only in the large urban areas.

BELGIAN

The Belgian organization differs from the British in that the

actual direction of field work comes from an office at the Ministry of Colonies in Brussels. Perhaps as a result of this centralization, more stress has been laid on the wider aspects of surveying such as major triangulation and the publication of topographical maps.

The survey of Katanga is organized separately by the *Comité Spécial du Katanga*, also with offices in Brussels, which directs both geographical and geological work. Since the Katanga administration has developed independently as regards research, a few details of its programme may be given. The first object is to establish a geodetic network of triangles over the whole country to serve as a foundation for maps showing topography, soils, geology, and vegetation. The network at present extends over all southern Katanga and most of the northern territory to the east of the Lualaba River. The next stage, which is complete for 10° square in the south of Katanga, is to make topographical maps, which are drawn on the scale of 1:100,000, and published on 1:200,000, the contours being inserted at intervals of 25 metres. The sheets already published give a very good idea of the province. They are referred to in subsequent chapters.

PORTUGUESE

As part of the recent reorganization of the Ministry of Colonies at Lisbon, a new department was established for geographical and scientific investigation, so that a centre now exists comparable with those mentioned above for the British, French, and Belgian colonies. In Angola and Mozambique there are large Public Works Departments which include sections devoted to survey and mapping. The area administered by the Mozambique Company has its own survey staff, and in the Tete District, between Northern and Southern Rhodesia, a special geographical mission has been at work for a number of years. In Angola the Ministry of Colonies is now organizing a special mission to triangulate the southern part of the Benguela-Mossamedes plateau.

FINANCE

During the years of economic depression from 1930 onwards, the survey departments of the Empire were more severely cur-

tailed than any other branch of the public service. It is doubtful, however, whether the economies realized in this way offset the waste that is incurred in development which is not based on adequate mapping. This argument for a comprehensive programme of high-precision basic surveys has long been stressed by experts, but its validity is not yet recognized by the general public.

The geodetic and topographical surveys of a new country are in fact as fundamental as roads, bridges, and railways, and therefore it can be argued that survey work, like other branches of development, should be financed by pledging the future and anticipating the increase in revenue at which development aims. All states view the financing of roads and railways as capital expenditure for which they will readily secure loans on general security. Yet, except in the Union of South Africa, Southern Rhodesia and one or two of the colonies[1] surveys are financed from current expenditure, so that it is impossible to make a long-term plan with any certainty that it will be carried out. The present system can be explained by the fact that surveys cost so little in comparison with roads and railways that they have not been considered as belonging to the same category. The effects are particularly unfortunate in the case of geodetic triangulation, where continuity is essential.

It is necessary to discriminate between the first production of maps and their subsequent maintenance. The former is properly a subject for capital expenditure and the latter for financing from revenue. The analogy with roads and bridges is here quite exact. The necessity for maintaining a map and of maintaining the bench marks and beacons on the land itself, a matter of considerable difficulty in parts of Africa, is very commonly forgotten. The topographical survey of the Orange Free State is an example of the importance of maintenance: the whole operation was a model of efficient organization, good technique, and able direction; time and usage have proved the resulting maps to be as reliable as they are artistic. The triangulation control was carefully carried out

[1] In the Union of South Africa approximately one-quarter of a million pounds have been expended from loan funds since 1903 upon the principal triangulation surveys. Since 1927 the annual vote has been £21,000; in 1935 £30,000 was provided from loan funds, the increase being for the topographical survey. The topographical survey of Sierra Leone was financed from 'Loans service' at a cost of £78,000.

and adjusted to the geodetic framework. The triangulation stations were marked but unfortunately were not permanently beaconed, and no arrangements were made for their protection or for keeping the map up to date. When the Trigonometrical Survey of the Union, organized in 1920, investigated the possibility of incorporating this triangulation, some fifteen years after it had been surveyed, so many marks were missing, that, on that score alone, the idea had to be abandoned and a fresh triangulation had to be extended over the province—an area of 50,000 square miles. In Kenya also, where land has been widely beaconed for cadastral purposes, survey marks are unpopular with natives, and as they cannot be expected to distinguish between triangulation and boundary marks they are apt to remove both indiscriminately. Much damage to the existing triangulation has already been done in this way, and the question of maintenance will require consideration before further geodetic survey is begun.

At the Conference of Empire Survey Officers in London in 1931, the following resolution was carried unanimously. 'In view of the immense permanent value of a sound framework of primary survey in the development of a country, and the proved difficulty of financing the execution of such a framework out of revenue, and in order to avoid needless confusion and waste of public money on surveys of a temporary nature which are being, and must inevitably be, undertaken: consideration should be given to the employment of loan funds for the immediate provision of an adequate and permanent controlling framework in all colonies where such does not already exist, or is incomplete.' This resolution received the approval of the Colonial Office which drew the attention of the Colonial Governments to it so that the views expressed might be borne in mind when schemes of development were under consideration. It appears, however, that little practical effect has been given to the resolution.

Another problem, perhaps equally important, arises from the difficulty of obtaining trained personnel at short notice. With permanent branches to deal with the geodetic and topographical work in a survey department, this difficulty does not arise in so acute a form. When schemes of survey are sanctioned, finance should be assured over a term of years in order to avoid these

difficulties with regard to staff. Moreover, the purchase of instruments would be tantamount to locking up capital, if they are not put to constant use.

On the whole it would seem that in any case geodetic survey and possibly also such topographical survey as is required in the more productive regions, should be financed from loans. Cadastral survey is in a different category; it is so closely connected with the raising of revenue that it may very well be made to depend on the revenue. Moreover, it can be taken up when and where wanted, because once the framework has been established it is not so necessary to presume continuity in the subsequent processes.

An annual budget may contain no item of expenditure for geodetic survey or topographical survey, but if departmental appropriations are carefully examined, it will sometimes be found that large sums of money are expended on surveys to provide maps or topographic data, the value of which is seriously limited through the fact that they have not been made as part of a comprehensive plan. For example, the South African Commission of 1921[1] stated that the Irrigation Department budget provided at that time for an annual expenditure of £19,000 and the Railway Department £11,000 for reconnaissance surveys, the greater part of which would have been unnecessary if there had been reliable topographical maps of the country. In 1933 the Union Government found it necessary to authorize a reconnaissance survey to provide a small-scale map of the Union on 1:500,000 (8 miles to 1 inch), estimated to cost £60,000 and to take three years to complete. This survey will not materially assist the general topographical survey of the country. Such unco-ordinated measures have no permanent value and are proportionately much more expensive than a general topographical survey.

STAFF AND TRAINING[2]

EUROPEANS

In the Union of South Africa the training of survey officers, which has a fundamental bearing upon the whole survey system, is organized in co-operation with the University authorities and

[1] See above, p. 29. [2] This section deals with British Territory only.

the Survey Board. Under this scheme, a university degree course in surveying can now be taken and the candidate receives an education and training in the general principles of survey in all its branches, analogous to that provided for other professions.

In the British Colonies there is a certain proportion of army-trained and Ordnance Survey-trained men, with traditions of topographical mapping, and between 1920 and the recent economic depression a number of surveyors trained at British Universities entered the colonial departments. Owing, however, to the fact that survey departments are expected to produce revenue by charging fees for surveys of property boundaries, some of the personnel who subsequently come to hold responsible positions, gain little experience of work other than that in property survey.

Some authorities hold that in many areas in Africa survey work can best be carried out by officers and men seconded from the Royal Engineers, the reason being mainly that geodetic survey is best handled by a central organization. It is true that this method costs less than the maintenance of large local survey departments, but if, as usual, an officer has only a short term of duty in Africa, part of that time must be spent in learning the local difficulties and these must be learned afresh by his successor. Officials in Africa have said that this lack of continuity has hampered the progress of mapping in many areas. Particularly on the West Coast it has been asserted that the work done by Royal Engineer officers is generally no more accurate, though more expensive, than that done by civilian personnel. This does not apply to self-contained pieces of work such as a boundary survey or a portion of a geodetic arc (see below), but for ordinary topographical work there are advantages in the employment of personnel who have to live where their maps are constantly under review and criticism.

While, therefore, for maintenance it is probably best to employ men whose careers lie in Africa, for first production there are advantages to be gained by making use of military personnel in some colonies, at any rate until such time as local cadres can be built up. The justification for using army personnel is that the experience is valuable and that the army is willing to pay for it to the extent of bearing the cost of part, or all, of the salaries of the officers if necessary.

AFRICANS

In some territories much of the routine fieldwork, such as plane-tabling and drawing, is generally done by highly paid European officials, though it could be done efficiently by suitably trained Africans. In West Africa natives are employed much more for these purposes than in the East, and it is worth recording the number of staff for purposes of comparison. In the Gold Coast the European staff consists of fifteen, the duties of five of whom are mainly administrative; two work on the triangulation framework, one is in charge of topography and three are on cadastral survey. There are forty-five African surveyors who do all the field work, with the exception of the main triangulation and the observation of astro-radio points, and require very little supervision. In the drawing, computing, and printing offices of the department, each of which is in charge of a European, forty-six Africans are permanently at work. These offices prepare all the diagrams and drawings required by other government departments, and also print maps for Sierra Leone, which started its own topographical work in 1927. To train this large African staff a special survey course of three years was organized by the department and ten pupils per annum were passed out as surveyors. The school was closed down in 1930 as a result of economy cuts, but was reopened in October 1937. Any boys passing out of the survey school could sit for the licensed surveyors' examination and undertake individual property work for mining concessions, etc. A large number did so, and there are now only three European licensed surveyors still at work in the Gold Coast. The department of Nigeria is roughly the same size as that of the Gold Coast, there being forty-three African surveyors, including two on staff appointments on a par with Europeans, forty draughtsmen and seven lithographers. The department likewise has its own drawing and printing offices and had until recently its own survey school.

In East Africa, courses in surveying are given in Uganda and Tanganyika, where students from Zanzibar are also taken; but shortage of skilled African personnel is acutely felt. The Director of Lands and Mines in Tanganyika recommends the centralization of a training establishment at Makerere, whence the East African group of territories could obtain recruits. His colleague in Uganda,

however, prefers a system of departmental training (East Africa 1937). Brigadier Winterbotham has suggested that African surveyors could be recruited through military channels, and has pointed out that the King's African Rifles already train numbers of signal boys; he considers that a similar education directed to surveying would supply the right class of material. As an example of the use of military training, in Northern Rhodesia the survey platoon of the King's African Rifles was absorbed by the survey department in 1932. The personnel was originally selected from natives of a very low standard of education, but a limited number of them, after two years' training in the drawing office, are now producing work of a high standard. These proposals by Brigadier Winterbotham were not, however, adopted by the governments concerned.

Against the view that African surveyors should be recruited on military lines it may be urged that some background of general education is desirable. Furthermore cadastral survey, which provides fixed and mechanical tasks, is probably the best immediate apprenticeship for topography which, more than any other surveying operations, calls for individual judgement. It appears that the only satisfactory way of training Africans for survey work is to obtain candidates of as good educational qualifications as possible and give them a three or four years' technical course, which will include both theory and practice, at a properly constituted school or training institution.

There seems to be a general demand for native auxiliary staff in all East Africa, except perhaps Kenya, where there is no use for plane-tablers at present, because the topographical work is at a standstill. In Kenya, moreover, there is no printing office for the reproduction of maps (other than sun-printing by hand), so that there is no demand for skilled labour in printing, and most of the drawing is done by Indians.

RESULTS

GEODETIC TRIANGULATION

As has been emphasized above, relatively little geodetic work has been accomplished in Africa, compared with most other parts

of the world. The British territories, other than Northern Rhodesia and Nyasaland, and most of the non-British areas have completed a primary triangulation network over the more important areas, and some secondary and tertiary triangulation has been done, so that maps can be drawn individually, but there is little to connect these separate pieces of work. Thus Sierra Leone, the Gold Coast, and Nigeria have reasonably accurate maps which are in no way correlated across the intervening French territories.

In certain noteworthy instances international co-operation has led to the thorough demarcation of boundaries on a geodetic basis, such, for instance, as the Congo-Angola boundary, the Congo-Uganda boundary surveyed in 1908, and the boundary between the Anglo-Egyptian Sudan and French Equatorial Africa, settled in 1921–3. But many international boundaries are ill-defined, and there are cases on record where points fixed astronomically many years ago have been found recently to be as much as 10 or 20 kilometres in error. It is obvious that, should mineral resources be discovered in the neighbourhood of international boundaries, errors of this magnitude may lead to difficulties; but a much more potent reason for proceeding immediately with geodetic triangulation is that the lack of framework has held back topographical and cadastral work.

The geodetic work essential as a preliminary to an adequate survey of Africa comprises two or three meridional chains and at least as many parallels at right angles to them, cutting across all international boundaries. In the immediate future the piece of work which demands attention is the completion of the arc of the 30th meridian. Later the parallel of 10° north may be looked to, passing through French Guinea, Sierra Leone, the Gold Coast, Togoland, Dahomey, Nigeria, the Cameroons, the French Sudan, Abyssinia, British Somaliland, and Italian Somaliland. A chain of triangulation fixed along this parallel will greatly assist the demarcation of the boundaries. It is worth noting that the present programme of the Gold Coast survey department includes the measurement of a chain of triangulation between Wa and Gambaga in the northern territories, lying between the 10th and 11th parallels.

In recent years British policy has been to regard geodetic tri-

angulation as the responsibility of the local administrations, but lack of resources and trained personnel make it difficult for them to carry out the work. Other geodetic work, together with levelling with a view to topographical maps, is progressing well in certain British territories, particularly Nigeria, the Gold Coast and Tanganyika. In the Gold Coast the full survey is complete as far north as 7° 30′ N. latitude, and the framework to 10° 30′ N. Nigeria, having a much greater area, is not so well placed, and the Surveyor-general estimates that an expenditure of £15,000 to £20,000 is required to complete the framework, after which the department will be in a position to proceed steadily with topography. In Tanganyika a scheme was prepared in 1925 primarily with the object of incorporating all known triangulations within a proper net, the chains of triangles being arranged to pass through the areas of most economic importance, as indicated by the presence of minerals, European colonization and dense native population. A loan of nearly £24,000 was received from the Colonial Development Fund, and progress has been rapid. This survey will form the subject of a special report by the Director of Surveys, and summaries of progress, with maps showing the completed and proposed chains of triangles, are included in recent annual reports of the survey department.

In the Belgian Congo geodetic surveys have been carried out in the following regions: for the Bas-Congo, a boundary triangulation has been almost completed along the Belgian-Angola boundary by collaboration between the two administrations. The boundary between the Congo and Northern Rhodesia has also been fixed by triangulation from the Luapula River to the Congo-Zambesi divide, and along the divide as far as the 24th meridian East; this was done by Belgians and British in collaboration. In Ruanda-Urundi, a complete secondary triangulation has been carried out and another line of secondary triangulation extends westward from the north end of Lake Albert. Commandant Maury, the Director of Surveys at the Belgian Ministry for Colonies, has planned a line of triangulation roughly following the fifth parallel south, in order to join the Bas-Congo with the Ruanda triangulation and the 30th arc when complete. Then it is proposed to work round the great north bend of the Congo from the Bas-Congo to

join the fifth parallel about where it cuts the 27th meridian. Maury (1934) has published a detailed account of all the triangulation in the eastern part of the Congo. A large part of the Katanga has been triangulated by the Service Géographique et Géologique du Comité Spécial du Katanga.

In Mozambique geodetic triangulation has been carried out on the frontiers and in the Tete District, where 130,000 square kilometres have been covered. This system has been carried along the parallel of 15° South and connects with the main triangulation chain of the Rhodesias. In Angola geodetic triangulations have been carried along most of the boundaries by special commissions, but in many areas framework for mapping depends on points located by astronomical observations. Similarly in Portuguese Guinea, geodetic work is limited to the frontiers.

A correlation of triangulation in the Congo, Kenya, Uganda, and Tanganyika by connection with short chains of triangles would be desirable. The Uganda triangulation is based on a small completed sector of the arc of the 30th meridian, and work in Tanganyika will connect with the sector of this arc recently completed there, but correlation cannot be entirely satisfactory until these two sectors are joined and a wider gap to the north of Uganda is also filled. Therefore, the history of the triangulation of the 30th arc and the possibilities of continuing it are summarized in the following paragraphs based upon an Ordnance Survey Publication (1933).

ARC OF 30th MERIDIAN

Proceeding northwards from South Africa, the section of this arc through Cape Province, Transvaal, and Southern Rhodesia was completed at the beginning of the century under Sir David Gill, and was continued in Northern Rhodesia in 1903–7 (results published by the War Office in 1933). This work was resumed in 1931–3 and extended to the boundary between Tanganyika Territory and Ruanda-Urundi under Major Hotine, a distance of 402 miles at a cost of £17,000, funds being provided by the Northern Rhodesian and Tanganyika Governments and the Colonial Development Fund. From here there is a gap in Ruanda-Urundi of 315 kilometres from 4° 20′ S. to 1° 30′ S., followed by a small strip

of Tanganyika of 55 kilometres, 1° 30′ to 1° 00′ S. For the completion of this small stretch the Belgians are ready to co-operate and have finished the preliminary reconnaissance work. Alternatively it could be carried entirely through British territory by deviating through Tanganyika, at an approximate cost of £2,000, if in conjunction with other work, or £6,000 if the subject of a special expedition.

Passing north, the Uganda sector from 1° S. to 10′ N., was completed by a special Anglo-Belgian operation carried out in immediate sequence to the Boundary Commission of 1908. Following on this, there is a large gap comprising a small piece of Northern Uganda, 275 kilometres, and the whole of the Sudan, as far as the Egyptian border at 22° N. The portion from the Egyptian frontier to Cairo was completed in 1930: quoting from a statement by F. S. Richards: 'Geodetic survey was started in Egypt in 1908 with the object of completing the Egyptian portion of the 30th meridian arc. Before starting work Captain H. G. Lyons (Sir Henry Lyons) sought the best advice available and eventually decided to use methods similar to those used by Sir David Gill at the Cape. So well was the foundation laid that there has been practically no change in methods or instruments up to the present time. The triangulation chain from Cairo to Halfa, which is claimed to have as high a degree of precision as any geodetic survey in the world, was completed in 1930.'[1]

The importance of completing this arc is stressed by every authority on the subject. The Ruanda-Urundi gap would be easy to close, since the country is open and most of the necessary expensive instruments used recently by Major Hotine are already in use by the geodetic branch of the survey departments in Tanganyika and in Northern Rhodesia. The Sudan gap presents greater difficulties; the northern part from the Egyptian border to Khartoum is easy desert country, and its completion would consist simply in extending the Egyptian work, but the southern part from Khartoum to Uganda cuts directly through the sudd area of the White Nile, where triangulation is recognized to be impossible, so deviation is necessary. The best way would be to make a complete circuit round the sudd area, but, if this involves too much work,

[1] Private Memorandum.

valuable results would be achieved by deviating to the east along the Abyssinian-Sudan frontier and thus fixing this vague frontier on a geodetic basis. It has been estimated roughly that £40,000 to £50,000 would be necessary for this work, which, with £2,000 for the Ruanda sector, makes a heavy sum, most of which would be expended on salaries for European officials. The outlay would be large but by the time the work was finished there would already be some return of an indirect kind. Brigadier Winterbotham has pointed out, moreover, that the completion of the 30th arc would cost Africa very little if the War Office were persuaded to lend staff. Engineer officers have to gain experience, and work in this region would provide the best possible training.

TOPOGRAPHY AND PUBLICATION OF MAPS

An important centre for British Africa is the Geographical Section, General Staff, of the War Office, where small-scale maps are published for all British Africa and maps of foreign territories are prepared when required for strategic purposes. The principal series is on a scale of 1:2,000,000 (31½ miles to the inch), and covers the whole Continent in thirty-four sheets, of which most are now on sale. This series is published by the British War Office and the French Service Géographique de l'Armée in collaboration, but the data on which maps are based are usually provided by the territories themselves; for instance the Belgian Congo provided documentation for the two sheets covering the Upper Congo and the Congo Forest. The French Service has also just completed the publication of a 1:5,000,000 series covering the continent in twenty-four sheets. Of the 1:1,000,000 series, eighty-two sheets are published. The Geographical Section, General Staff, has in the past published a number of topographical maps of British territories, on scales of 1:250,000, and 1:125,000, but it has handed over this duty to local survey departments where these have been formed. Thus it no longer tries to maintain any series besides the 1:2,000,000, except for countries like Somaliland where no survey organization exists. It should be pointed out that many of the old 1:250,000 maps are little more than reconnaissance sheets. To suggest how unsatisfactory the maps of ten and twenty years ago are for present purposes, it is worth instancing a recent case where an engineer made an

eleven-mile error in the position of an important steel bridge by mistaking a 1913 mail-runner's path marked on the map for the 'great north road' of 1925.

The old plane-table surveys were incorporated in a series of sheets on a projection reasonably good for the purpose, and on a well thought out numbering and arrangement. But as triangulation grows, and as the property surveys come into a rigid framework, it becomes important and economical to work upon a more flexible projection. South Africa already has such a system, but has adopted certain methods which are unsuitable for topographical purposes. Accordingly Brigadier MacLeod, after the Conference of Empire Survey Officers in 1931 and again in 1935, put forward an alternative method for projection of the 1:250,000 series, whereby the whole of Africa is divided into meridional belts each representing six degrees of longitude.[1] His memorandum on the subject has been circulated to survey departments, etc., and it seems highly desirable that some international agreement should be reached. Commandant Maury has already used a somewhat similar scheme for projection by dividing part of the Belgian Congo into meridional belts.

It would clearly be desirable that a unified system of map projection should be adopted at an early date by all countries holding territory in Africa. The rate of publication of maps is accelerating so rapidly that a change in the method of projection, say in ten years' time, would entail great cost and perhaps for this reason alone could not be accomplished.

This question is closely connected with that of the unit of measurement to be adopted. The international metre is the only unit to which the French, Belgians, Italians, Portuguese, and Spanish Governments are likely to agree. Egypt already uses the metre, and the case for its adoption generally appears to be very strong, as pointed out by Brigadier MacLeod (1936). It would involve certain difficulties in the British territories, where the survey work so far done has been in feet, particularly since, if the metre were adopted, the change would probably have to be extended to cadastral surveys. A full statement of the various argu-

[1] 6° belts were unacceptable to Tanganyika, where work is in progress using meridional belts of 5°.

ments for and against the change to the metric system cannot be given here, but as far as topographical maps are concerned there is a strong case for the adoption of a unit of length which is not only the scientific, but also the only unit which can ever become truly international. It is worth remembering that in the future Africans themselves will enter more and more into active participation in surveying, and that they are the people who actually use maps even more than the British. Also it is significant that a considerable part of British Africa already has the decimal system in coinage.

Many maps of Africa are published locally by the printing and publishing offices of the Dominions and Colonies. Since some of these publications are not readily available in other parts of the continent or in Europe, reference is made to the more important 'series' and 'general' maps.[1] All African territories are included, not only those south of the Sahara, with which the African Research Survey has been primarily concerned.

In addition to the maps referred to under the separate territories, the series on the scale of 1:1,000,000 of the Carte du Monde are valuable. This series has already covered the greater part of Northern Africa and a number of sheets have appeared for East Africa and a few for the southern part of the continent. Full details of the publications to date are to be found in a report issued by the Central Bureau of the Carte du Monde (Ordnance Survey 1937). The Carte du Monde represents international effort to co-ordinate the maps of the world, which has been in progress for some years, and the publications indicate the important results achieved.

British

The *Union of South Africa* has published an excellent general map on 1:1,000,000 and has in contemplation a topographic series on 1:500,000, but no sheet has yet appeared. The War Office series on 1:250,000 of a portion of Cape Colony is still the only topographic map of that province. The Orange Free State has a topo-cadastral series on 1:125,000; Basutoland is embraced by the War Office 1:250,000 series. The Transvaal has a Degree sheet

[1] A list of these has been kindly provided by Brigadier MacLeod.

series (farm area map), on 1,000 cape rods to 1 inch, and similarly Natal has a 1-inch (farm area), series, but for general topographical maps these two provinces are less well provided than some of the colonies such as Uganda or Nigeria. For the Mandated Territory of South-West Africa, there is an excellent 1:500,000 (covering about 90 per cent of the country), compiled and drawn in the Surveyor-General's Office, Windhoek.

The *Southern Rhodesia* Survey and Geological Survey Departments have produced isolated topographic maps for land development and the former has published recently a 1:500,000 and a 1:250,000 series.

For *Northern Rhodesia* the old 1:1,000,000, published by the War Office, is still regarded as the standard map, though recognized to be inaccurate. The territory is also covered by a local roughly compiled map on 1:250,000. This is being superseded by a greatly improved and more reliable series on the same scale which will embody the recent air surveys.

For *Nyasaland* the old War Office publications on 1:1,000,000 and 1:250,000 were found by the Lands Officer to be seriously out of date by 1922. Information from District Commissioners and others has been incorporated in a new general map on 1:1,000,000 and in district maps on 1:250,000, which are published locally by the Lands Office. More accurate maps cannot be prepared without a triangulation survey from which the topographical details can be developed.

The whole of *Tanganyika* is covered by a War Office 1:1,000,000 series compiled during the War from very indifferent material. The Survey Department has recently done some topographical work in connection with land development; so also has the Geological Survey Department. A series of square degree sheets on the scale of 1:250,000 are being compiled and a number are already published.

Zanzibar Island is being topographically mapped on the 6-inch to 1-mile scale by the local Public Works Department and Pemba Island is published on 1-inch to 1-mile by the War Office.

In *Kenya* organized topographical surveys were begun in 1908 and ended six years later when the officers and N.C.O.s of the Royal Engineers were recalled to their units on the outbreak of

war. The series of maps published by the War Office are on a scale of 1:250,000, and a few sheets on 1:125,000. These cover about one quarter of the country, and the remainder will be incorporated in a new War Office 1:500,000 series now in hand. The country therefore relies on maps which are now much out of date and do not show roads, but the original fieldwork was of a high standard and the sheets could be cheaply and quickly revised. The Trigonometrical and Topographical branch of the Survey Department was finally closed down in 1921, when the Government decided that the only essential surveys were those of farms and town plots for alienation. After the visit of Brigadier Winterbotham in 1929, a proposal was made to revive the topographical section on a small scale with a view to this revision, but this was rejected as part of the economy measures of 1930. The only topographical survey of any importance which has been carried out since the War is one of a portion of the Kakamega Goldfields which was done in 1932 on a scale of 1:62,500. It is clear that a topographic branch and a publishing office are badly needed as additions to the Survey Department.

Uganda, which publishes its own maps, showing roads and other recent developments, has 1:1,000,000 and 1:500,000 maps of the whole country. Also there are produced a 1:50,000 series, designed as a key to property surveys combined in some areas with topography, and a topographic 1:250,000 which, with the rather out-of-date War Office series on the same scale, covers more than half of the country. For the remainder, compiled 1:250,000 District maps are available.

The *Nigerian* Survey Department has produced compiled maps on 1:1,000,000 and 1:500,000 which are kept well up to date. There are also recent topographic maps on 1:125,000, and 1:62,500, but only a relatively small area is at present published (about 12 per cent of the area in the 1:125,000 series). For geographical purposes the Survey Department published in 1933 a valuable series of 1:3,000,000 maps of Nigeria, showing relief, communications, temperature, rainfall in wet and dry seasons, vegetation, population density and products. These were modified and reduced for inclusion in the Handbook of Nigeria (1933).

The *Gold Coast* Survey Department produces topographic series

on 1:250,000, 1: 125,000, and 1:62,500; the combined area covered represents about 80 per cent of the country, but of this 21 per cent was done before the war and is now seriously out of date. During the depression the topographical branch was cut down to a mere nucleus and very little new survey—apart from revision—has been done. The department considers that it is not advisable to undertake further topographical work in the Northern Territories until the possibility of air survey has been investigated (see page 58). In 1935 the Survey Department published a useful atlas of the Gold Coast including fourteen maps of the whole territory on a scale of 1:500,000, showing geographic data such as relief, geology, population, rainfall, forests, products, etc.

Sierra Leone has been topographically surveyed on 1:62,500 by the local Survey Department, but so far only about half of the sheets have been printed. The War Office 1:500,000 map is based on this survey, but contours are not shown.

For the *Gambia*, which has only a Lands Department, the only general maps are the War Office publications on 1:500,000 and 1:250,000.

Somaliland has no Survey Department. The only maps are War Office publications on 1:1,000,000 and 1:250,000. The latter, much out of date, will be superseded by a new series now in preparation.

The *Anglo-Egyptian Sudan* Survey Department publishes a compiled 1:250,000 series which is systematically revised as new data accumulate. It publishes also International 1:1,000,000 sheets.

Egypt

The seven sheets of the International one million map which cover Egypt were completed in 1934. In addition to these the whole country is covered by a provisional 1:500,000 which soon will be superseded by a better series. Lower Egypt, the Nile to Aswan, the Red Sea Coast, the Northern Littoral and the whole Peninsula of Sinai on the 1:100,000 scale, and nearly all Lower Egypt, some of the oases and part of the Nile are topographically mapped on 1:25,000. All these maps were produced in Egypt. For Northern and Central Sinai the War Office 1:250,000 and 1:125,000 series are still the only contoured maps, but these are being replaced by a new series produced in Egypt.

French

For general maps of all the French territories the magnificent *Atlas des Colonies Françaises*, edited by M. Grandidier (1933), is a most important reference work. It includes orographical, political, geological, rainfall, economic, and other maps, and must be of great value to all concerned with administration or development. Such a publication for the British territories would be invaluable.

The Service Géographique de l'Armée, Paris, publishes of *Algeria* 1:200,000 and 1:50,000; of *Tunisia* 1:200,000, 1:100,000, and 1:50,000; the same Department and its sub-section, the Service Géographique du Maroc, produces 1:200,000, 1:100,000 and 1:50,000 of *Morocco*. There is also a general series on 1:500,000 which extends well into the Sahara.

For *French West Africa* the Service Géographique de l'Armée reproduces the final editions of the maps prepared by the Service Géographique de l'Afrique Occidentale Française at Dakar. All French West Africa and the adjoining countries are covered by sheets on the 1:1,000,000 scale published in Paris and the Dakar department has produced a compiled series on 1:500,000. There is in addition a 1:200,000 series of parts of Senegal, Guinea, the Ivory Coast, Niger Colony, Sudan, and Mauritania, a 1:100,000 of a small part of Senegal and of Southern Dahomey, and a 1:50,000 of part of French Guinea.

For *French Equatorial Africa* there is a 1:1,000,000 map published in 1935 by the Service Géographique de l'Armée. Other small-scale maps have been published by the same organization and by the Ministry of Colonies.

The *Cameroons* and *Togoland* areas administered by the French are covered by the 1:1,000,000 mentioned above. They have no general series other than the German compiled maps on 1:300,000 for the Cameroons and 1:200,000 for Togoland. Small-scale maps of both areas are published by the Ministry of Colonies, Paris.

French Somaliland is mapped by the same Ministry, the largest scale being 1:500,000.

Madagascar has an active survey and mapping establishment. It possesses 1:200,000 and 1:100,000 topographic maps which mark steady progress. Various small-scale general maps are also produced.

Belgian

The Belgian administration has carried out a large-scale programme of map production, the results of which are of high value. A 1:5,000,000 map of the whole Congo, for instance, is published in five editions, political, communications, orographical, hydrographical, and geological. The whole Congo is covered also on the scale of 1:1,000,000, and a new series on 1:500,000 compiled from all sources is in production. There is a rough topographic series on 1:100,000 of the lower Congo and a provisional 1:100,000 of Ruanda-Urundi. All of these are published by the Ministry of Colonies, Brussels.

The *Comité Spécial du Katanga* is publishing an excellent contoured 1:200,000 series of their territory. The topographical, geological, soil, and vegetation work is published in maps and separate leaflets as well as in the magnificent Atlas du Katanga (1929 onwards).

Italian

Tripoli and vicinity is mapped on 1:200,000, 1:100,000, and 1:25,000; *Benghazi* and the adjoining country on 1:200,000, 1:50,000, and 1:25,000. For the whole of Libya there are compiled series on 1:800,000 and 1:400,000, neither of which is complete. The Instituto Geografico Militare, the Ministero delle Colonie and the local services of Tripolitania and Cirenaica have all participated in the mapping of Libya.

Eritrea is mapped by the Instituto Geografico Militare and the Ministero delle Colonie. For the whole country there is a compiled 1:400,000, and contoured 1:100,000 and 1:50,000 series exist for small areas.

For *Italian Somaliland* the Ministero delle Colonie is publishing a compiled series on 1:400,000; about one-third of the colony is completed. A small area in the Lower Juba Coastal region is covered by topographic maps on 1:200,000, 1:100,000, and 1:50,000. Various small-scale maps are prepared by the local geographic office at Mogadishu.

Abyssinia

There are no maps published in Abyssinia. General maps have been published by the British War Office and the Italian Colonial

Office, the scale in each case being 1:2,000,000. The best map, on 1:1,000,000, was produced in 1934–7 by the Instituto Geografico Militare, covering all Abyssinia. The frontier areas are also well covered by the series of the adjoining countries.

Portuguese Colonies

Angola is mapped by the Ministerio das Colonias, Lisbon, 1:1,500,000 being the scale adopted.

Mozambique is mapped by the same authority. Three International 1:1,000,000 sheets have appeared, but the best map is by the Direcção dos Serviços de Agrimensura, Lourenço Marques, on 1:1,000,000.

Portuguese Guinea is mapped on 1:500,000 by the Ministerio das Colonias.

Spanish

For *Morocco* maps from 1:1,000,000 to 1:100,000 of part or the whole of the territory exist, and a new 1:50,000 topographic series is in rapid production.

Rio de Oro, *Ifni*, and *Spanish Guinea* are indifferently surveyed. The best maps are made by the Madrid Geographical Society.

Liberia

The maps of this State are not much more than skeleton in form. The latest, called a preliminary base map, is published by the Department of State, Monrovia, on 1:600,000.

AIR SURVEY

Recent development in air survey has led many to suggest that in it lies an obvious solution to the problem of mapping the enormous unsurveyed areas of Africa, and much enthusiasm has been expressed at the rapidity with which results have been achieved. On the other hand some authorities, while appreciating the great value that air survey can render in certain special circumstances, consider that general mapping programmes can be carried out more efficiently and more economically by the well-tested methods of ground survey. In order to appreciate air survey

in relation to other branches of development, it seems best to consider the value of air photography in two aspects: (1) as a method of making maps, and (2) as a means of showing the resources of a country apart from the mere plotting of physiographic features.

It should be realized that the air photograph cannot in any way replace triangulation, the fixing of a number of prominent features to form the groundwork for a map. It is in the later stages of survey, for which the plane-table is generally used, that the camera has many advantages. For topographical air survey in country like so much of Africa, where the triangulation network is incomplete or non-existent, strong ground control parties are required in order to fix the position of features which can be recognized in the photographs. The minimum distance between ground control points depends, of course, on the scale of mapping, but as a rule such points cannot be more than about ten miles distant from each other on account of photographic distortion. Using a wide-angle lens or a multilens camera for small-scale work, it is claimed that the distance can considerably exceed this figure without loss of accuracy.

In highly mapped countries like Great Britain air survey has proved of much value in bringing existing maps up to date by showing recent developments in the form of buildings, roads, and rails, and this type of air survey has been applied also in Tanganyika in connection with town-planning, etc. It represents a special case, however, and has little to do with the question at issue—whether the aeroplane and camera have advantages over the theodolite, level, and plane-table in the mapping of unsurveyed areas. In putting forward a few arguments both for and against air surveying in the following paragraphs, it is not intended to suggest that it is an alternative to ground surveying, but rather that the aeroplane and camera are instruments of survey which can with advantage be added to those in more general use.

The time and cost of air and ground surveys have often been compared. At a discussion on Topographic Air Survey at the 1931 Conference of Empire Survey Officers (1932), it was concluded that for small areas of open undulating country the plane-table is cheaper, but for large areas this is probably not the case. Against this, recent experience of the Survey of India was that ground

work proved to be cheaper in a country which would appear to be much more suitable for the camera than is most of Africa. Comparison of cost is not really very helpful, however, because air survey is valuable particularly in those places where ground survey, owing to lack of communications, can either not be done at all or is unduly expensive. In swampy country such as the sudd region of the White Nile, and possibly round Lakes Bangweulu and Mweru, the advantage lies entirely with air work. In heavily forested land also, the general configuration can be shown more cheaply by air survey, although details like bush paths may be obscured. Such features can best be inserted by ground traverses after the photographic mosaic is complete.

A topographical map must of course be reasonably accurate in three dimensions, and although contouring from air photographs gives promise of a great future, it cannot yet compete in cost or accuracy with ground work, except in special types of country such as precipitous or broken land covered with vegetation, where ground survey is exceedingly difficult. H. Hemming (1933) gives an example of such a case in South America where air survey for a proposed railway line proved to cost one-eighth as much as estimates for work on the ground.

A full account of methods used in surveying from air photographs has been published by Major Hotine (1931). Two methods are commonly employed. One consists of taking oblique photographs and scaling them to the form of a plan by means of a vertical grid. This method shows general topographical features, but is of little value for contours or for ascertaining land potentialities.[1] The other method employed for contouring from the air depends on taking vertical photographs always in overlapping series, from which trained draughtsmen can plot heights by stereographic methods. The mosaic of photographs together with the map drawn from them gives a complete picture of the land and is most useful for revealing natural resources, but the method is expensive and can only be employed where the land is already known to have high potential value, for mineral resources, forest exploitation or farming. The time required for the cartographical

[1] Contoured maps have been made from oblique air photographs for some parts of the world, for instance East Greenland. The necessary apparatus is very costly and does not exist in either Great Britain or Africa.

stages of aerial survey is very considerable, and since the cost of draughtsmen capable of contouring from air photographs may be as high as, or higher than, that of the plane-tabler who works in the field, it is clear that claims for extreme rapidity or lower costs of air survey should be made with caution. The perfecting and speeding up of a mechanical technique for contouring from air photographs may be hoped for before many years pass, and should then alter the balance in favour of air work. Another and more recent review of methods of air survey and the apparatus at present available is given in the second Report of the Air Survey Committee (1935). This Committee grew from a suggestion of the Army Council in 1919, and now includes representatives of the War Office, Air Ministry, Admiralty, Ordnance Survey, and Department of Scientific and Industrial Research. An appendix to their most recent report analyses the cost of air survey based on the future existence of an air survey organization on a permanent basis, undertaking operations on a large scale. In undeveloped country where land transport is difficult, the cost of survey is estimated for an area of 1,000,000 square miles, which would entail six years devoted to air photography. The total cost, including photographic material, but not the production of maps, works out at 23s. per square mile. For smaller areas this cost would be considerably more, rising to 180s. per square mile for an area of 500 square miles, and it would be much higher in urbanized areas. At present the situation with regard solely to the production of maps may be summed up in the words of Brigadier MacLeod who, as former Chairman of the Air Survey Committee, is by no means an antagonist: 'Wherever there are sufficient communications, or there is a reasonable choice between the two methods as alternative, ground methods are, from the purely survey point of view, almost always better for a given standard of accuracy.'

Air survey provides, however, not only topographical maps drawn from the photographs, but the photographs themselves, and this introduces the second aspect of the question, namely air photography as a means of showing the natural resources of a country. In choosing routes for railways and roads, sites for townships and so forth, air photographs have already saved much laborious ground work in some places. In addition to this the distribution of vegeta-

tion, and geological features, such as outcrops, faults, dykes, and sometimes even the location of mineral resources which would be unnoticeable to the ground worker, can be seen at a glance by the expert. The differences in soils can often be revealed by the actinic eye of the camera, and recent work in Australia has shown that on flat plains much can be learned concerning underlying geological structures by studying soil in this way. The type and extent of native agriculture and the location of native villages can also be seen at a glance.

As a particular example, though not from Africa, reference may be made to the recent air survey of the forest-covered Irrawaddy Delta, carried out in 1924 (Kemp and others 1925). The total cost was under Rs. 300 per square mile compared with about Rs. 500 for ground work which would have given no indication of forest types. The time for all stages did not much exceed one year compared with some three to four years on the ground. The Irrawaddy Delta is far more favourable than most of Africa by reason of its lack of ground relief, but the example shows the advantage of air survey under suitable conditions.

The only air survey carried out by Government in British Africa has been in Tanganyika, where an Air Survey Section was established in 1931. Since then, most of the important townships and harbours have been photographed, and in 1934 assistance was given to the Zanzibar Government in taking air photographs for town-planning and cadastral purposes (Tanganyika 1933, *D.R.*).

The principal companies which have operated in Africa to date are: H. Hemming & Partners, Ltd., who, through the agency of their operating companies, Geological Air Surveys, Ltd., and African Air Surveying Co. (Pty.) Ltd., have carried out extensive operations in South Africa, principally for mining companies. An air survey of the Witwatersrand Reef is in progress at the moment. Mr. H. Hemming (1933 and 1934, etc.) has written a number of articles stressing the value of air work both in mapping and in revealing natural resources. The Aircraft Operating Company, Ltd., and the Aircraft Operating Company of Africa, Ltd.,[1] have

[1] This branch company with headquarters at Johannesburg is now in the charge of Mr. Robbins who has stressed the value of air photographs in plant ecology and whose work in this connection is mentioned in Chapter vi.

undertaken a variety of surveys on various scales from 1:4,800 to 1:250,000. In Northern Rhodesia an area of some 72,000 square miles was mapped on the smaller scale for the Government for general administrative purposes, and in 1930 the Northern Rhodesia-Katanga Boundary survey was based to some extent on their photograph work. They have also photographed a large area of the Kavirondo District, Kenya, for prospecting companies, in connection with the recent gold developments, as well as a number of mining concessions in the Union and the Rhodesias. They mapped another stretch of country for the Beit Railway Trust which shows the Imperial Airways Route through Northern Rhodesia. It must be stated, however, that these surveys are uncontoured and therefore of small value for the development of communications.

These two companies have also interested themselves in the possibilities of aerial survey in West Africa, and have made preliminary inspections of parts of Nigeria and the Gold Coast. In the Gold Coast heavy vegetation in the Colony and Ashanti would probably make air survey impossible, or at any rate of little use for mapping, particularly since maps on scales of 1 inch and 2 inches to the mile are already published for the whole area; but an air survey of the Northern Territories has been proposed, though it is objected by the Survey Department that sufficient framework does not exist. In a few years, however, the primary framework will be practically complete and, once this is so, a concentrated effort on topography would soon establish fixed points which would be close enough to enable a survey from the air to be satisfactory. The lack of prominent ground features might be a difficulty, but this could probably be overcome by clearing small areas of bush or making other marks which would show up on the photographs. The fate of air survey in the Gold Coast will depend largely on the results obtained by prospectors who are now working on the undeveloped gold areas. If the fields are really valuable the expense of air survey will probably be justifiable.

The Air Survey Company has recently completed a very extensive piece of work in the Sudan and Uganda for the Physical Department of Egypt. It is concerned with the schemes for the proposed Lake Albert barrage and the possible deviation of the

Bahr-el-Jebel.[1] The work was hampered by bad visibility, particularly in the dry season, and the country is of course difficult, but it is quite certain that the mass of detail about the swamp areas could have been collected in no other way. For the purpose in view, precise levelling is required, of a higher standard than is usually included in ground control for air survey. The main lines of levels are already complete (Hurst and Phillips 1933).

In French West Africa, over the Gold Coast border where the country is open and the rivers give easy ground control, considerable areas have been photographed with success, and these activities are being extended. Another foreign area where air survey combined with thorough ground work has proved successful is the Lower Belgian Congo. This was done by the Compagnie Aérienne Française. Apart from this and the survey of the boundary between Katanga and Northern Rhodesia referred to above, no air survey has been attempted yet in the Belgian Congo except in a small corner of Katanga, where some air photographs have been used in preparing the detailed series of published maps. It was found to be too expensive and less efficient in results than ground work and so was discontinued, but this small experiment cannot of course be held to show that air survey is of no value in Katanga.

In the case of the surveys carried out by commercial firms under special contract for mining companies, the results are confidential and are not released to science for several years. Where photographs have been made available for examination, little advantage has so far been taken of the opportunity. More extensive use could be made of these results if local survey officers were trained to interpret them, but it must be remembered that a scientific understanding of the geology, soils, and vegetation of the region in question is at least as helpful in the interpretation of aerial photographs as any special training. In those parts of Africa where organized air surveys would provide the best basis for development the question of cost is important. The high cost of the air

[1] The proposal has been to construct an artificial watercourse from Mongalla, to the east of the sudd area, in order to join the existing channel of the River Sobat, which enters the main White Nile at Malakal. The result would be to circuit the sudd area, thereby reducing the enormous wastage of water which the sudd entails. Probably such a flow will be left along the present channel of the Bahr-el-Jebel, as can be carried without loss of water. This will enable water transport to follow its present route.

surveys so far made is due partly to the necessity of employing expert personnel for short periods. This difficulty might be met for the British dependencies by the creation of a permanent Air Survey Squad which could be sent to any area where information was desired at the moment. Owing to the long consecutive periods during which African weather conditions are suitable for photography, one operating aircraft plus strong ground parties could keep a considerable staff of draughtsmen occupied in making topographical maps. In order to make the results available to the various departments interested, liaison officers, to help in interpreting the photographs, might be required in the initial stages.

The desiderata of an Empire air survey organization are therefore: (1) Two or three aeroplanes with skilled staff. (2) Ground control officers to relate the photographs to fixed triangulation points. (3) A central headquarters with a technical staff to interpret the photographs and to prepare maps from them. (4) In the initial stages, experts to demonstrate the value of the photographs to local department officers.

CHAPTER III

GEOLOGY

INTRODUCTION

'IN every country in which a geological survey has been started the economic development of the mineral resources has been its real object and justification; scientific results are either accessory or contributory to this object, or they are by-products. But if the development of the mineral resources is the main object, the preparation of a geological map of the country is the chief method employed by a survey to reach this end.' This quotation from Sir Thomas Holland (1934) gives in a nutshell the application of geology to economic progress. The importance of the geological map cannot be over-emphasized, but geological surveys and maps are dependent in their turn on good topographical maps. A significant illustration of this fact is the development of the U.S. Geological Survey which eventually had to become responsible for all topographical, though not geodetic, surveying.

Although the revealing of mineral resources has been the main object of geology in Africa up to now, much of the work done by geological surveys is of more immediate interest to other departments as Sir Albert Kitson (1929) has shown. The characters of many soils, especially the sedentary types, depend in large degree on the nature of the underlying rocks.

In locating underground water-supplies geologists have been able to indicate large artesian basins, local basins, and waterlogged superficial deposits. Some geological departments actually undertake boring and well-sinking operations, and during the recent depression, the work of several of them was reduced almost entirely to problems of water-supply. In connection with the planning of public works, geological surveys are of value in dis-

covering rocks suitable for road metal and building material: it is economical to take the roads, if possible, through regions where such rocks occur. The structure and nature of underlying rocks and the depth of sound rocks below the surface are of the first importance when deciding on foundations for bridges, large buildings, dams and breakwaters.

The geologist makes his contribution to the science of public health by pointing out how the texture and porosity of underground strata are related to drainage and springs. In one case the cause of a typhoid epidemic was found to be a night soil depot on one side of a hill, the drainage from which passed through strata of porous rock and over the top of an underlying impervious stratum into a spring on the other side. The spring supplied a village which developed the infection.

Indeed, geological research, though popularly regarded as a purely academic pursuit, has a striking variety of practical applications.

ORGANIZATION

BRITISH

In the early years of colonial development the gathering of knowledge concerning mineral resources and geological structure was left entirely to prospectors and the few scientists who organized expeditions to study areas of peculiar interest. Later on, minerals surveys were arranged in several areas, under the control of the Imperial Institute, and these led to geological surveys, most of which were established since the war.

In the *Union of South Africa* official geological work started much earlier than elsewhere. A Geological Commission for the Cape was set up in 1895, and was followed by independent organizations in the Transvaal and Natal. The Natal survey was short-lived, but the Cape and Transvaal organizations were united in 1912 to form the Geological Survey of South Africa, which, with the Department of Mines, comes under the general direction of the Secretary for Mines. Of recent years the staff of the geological survey has been considerably increased, and in 1936 comprised a Director, an Assistant Director, twenty geologists, two mineralogists and two cartographers. Particular attention is being paid

to the study and development of the mineral resources of the Union, and recently a minerals development officer has been appointed to spend part of each year in London, in order to maintain close touch with the markets.

The *Southern Rhodesian* department, built up under Mr. H. B. Maufe (now retired), has done much work on the distribution of economic minerals. General geological survey is also well advanced and soils are a subject of particular study.

In the *Anglo-Egyptian Sudan* a Geological Department under Mr. Grabham has accomplished valuable work, though little has yet been published. The department is seriously under-staffed, there being one geologist to about a million square miles.

Nearly all the *British Colonies Protectorates* and *Mandates* have efficient Geological Departments and in ten or fifteen years valuable data have been accumulated. Exceptions are the Gambia, which was the subject of a special report by the Gold Coast department (Cooper 1927), and Somaliland, where the duties of Director of Agriculture and geological officer are combined.[1] Northern Rhodesia has no official department, but active geological work is carried out by mining companies. In Kenya extensive pioneering was done by the late Professor J. W. Gregory and others, but an official geologist was not appointed till 1933, after the discovery of the Kakamega Goldfields; the staff now consists of two geologists as part of the Mining and Geological Department.[2] Fortunately the men originally appointed as directors of the well-established Colonial Geological Surveys, such as Sir Albert E. Kitson in the Gold Coast (retired), Dr. E. O. Teale in Tanganyika (now appointed minerals development officer and spending part of his time each year in London), Mr. E. J. Wayland in Uganda, Dr. R. C. Wilson in Nigeria, Dr. F. Dixey in Nyasaland, and Dr. N. R. Junner in Sierra Leone (now transferred to the Gold Coast), have realized that economic research by itself is insufficient to ascertain the extent of mineral resources in an unknown country. Systematic geological surveys and mapping are necessary for the

[1] A survey of mineral resources was carried out in 1924 (British Somaliland 1924) and three petroleum surveys of various parts of the country have been made on different occasions.

[2] A geological survey of the north Kavirondo area, where the goldfields occur, is in progress, and the surveys made by concessionaires, as one of the conditions of their exclusive prospecting licences, add to the Government's information.

discovery, and especially for the proper development of these resources.

In most territories the geological departments embrace the subject of mineral resources, but the granting of mining licences and leases, and the preparation of statistics of production, are under the mining departments. Kenya and Sierra Leone have a Department of Geology and Mines united, and Tanganyika has recently amalgamated the former Geological Department, so that there is now a Department of Lands and Mines at Dar-es-Salaam, with separate divisions for Survey, Geology, and Mines at other centres in the territory.

The staff of these departments is small, and consists usually of four or five geologists of whom one or two may be specialist officers. Recruitment is usually made from graduates of British Empire universities. The opinion has been expressed by several directors that the right sort of men, suitably trained, are by no means easy to obtain. At present there are the following numbers of trained geologists in the departments: Nigeria—6, Gold Coast—4, Sierra Leone—1, Kenya—2, Uganda—4, Tanganyika—5, Nyasaland—3. Those departments which undertake well-sinking operations have in addition engineers and other European staff; for instance, Nigeria, which has devoted much attention to the water-supply of the Northern Emirates, has four engineers, five European foremen in charge of well-sinking gangs, and one driller.

Geologists in the Gold Coast and Sierra Leone spend six months of each year during the dry seasons working in the field and then return to an office in London during the wet season to work up the results. This system enables them to keep in close touch with other geologists in England, and allows time for the field results to be properly recorded. In Nigeria the geological department had the same system up till 1930, but then changed to eighteen months in West Africa, followed by six months' leave in England. In East Africa the tours comply with the usual two and a half years of other departments.

The difficulty for these small staffs of combining specialized research with routine work is great. In particular, the petrological and chemical sides of the work are severely handicapped. At present, Tanganyika and Uganda are the only territories with

petrological chemists permanently on the staff. Nigeria feels the lack badly, and the Director there is obtaining an African, trained in chemistry at the Higher College, Yaba, with a view to training him for routine analyses. At present in Nigeria the information gathered by the four field geologists cannot be used until the requisite analyses are made. Although a certain amount of analytical work can be done in England at the laboratories of the Imperial Institute and elsewhere, the long delay occasioned by sending material to England makes this an unsatisfactory arrangement. In particular the information obtained by preliminary determinations of minerals and assays must be prompt to be of value to prospectors.

With regard to palæontology the position is more difficult, since every specialist is an expert on only one or two groups of fossils. Hence, the departments must rely on specialists in England. In Africa, however, there are comparatively few areas where it is necessary to study stratigraphy in detail with the aid of fossils, because the greater part of the continent is made up of ancient or igneous rocks. Sir Thomas Holland (1934) considers that, from experience in Great Britain, U.S.A., Canada, and elsewhere, a minimum efficient staff for a geological survey should be twenty-one geologists, including at least seven specialist officers, such as petrologists and palæontologists. In view of the small funds available from colonial governments an increase in personnel to such numbers is impossible at present, but Sir Thomas Holland is fully convinced that geological and mines development would be greatly accelerated by the amalgamation of services in near-by colonies, according to the following groups: 1. Gold Coast, Nigeria, Sierra Leone. 2. The Rhodesias. 3. Kenya, Uganda, Tanganyika, Nyasaland.

This question is so important that it may be considered in rather more detail. With regard to the West African group of territories, the Directors of Geological Surveys, though agreeing that group amalgamation is desirable, do not consider that it is practicable at the present time, in view of the difficulty of communications. Moreover, the present staff consists of six geologists in Nigeria, four in the Gold Coast, and one in Sierra Leone, so that to reach Sir Thomas Holland's minimum number of twenty-one, the staff

would have to be doubled and heavy expenditure would be entailed in establishing suitable headquarters, laboratories, etc. Usually about one-third of the staff would be on leave. The difficulties involved in the creation of a unified headquarters are likely to be increased by delay, since each territory is developing its own reference collections and laboratory equipment. In Nigeria there are already two reference collections of minerals, those of the Geological Department at Kaduna and the Mines Department at Jos. Until amalgamation is practicable, facilities might be given to geologists to visit other British colonies and group conferences could be organized on the lines of the conferences of other departments, arranged in East Africa from time to time. At present stratigraphical correlation and progress in regional geological mapping are rendered difficult through the absence of collaboration between local departments. Exchange visits between geologists of our colonies and those of neighbouring foreign territories might also be encouraged.

Amalgamation in East Africa would involve a measure of financial co-operation and stability which is far from realization at present, since geological surveys are at present extensively financed only during periods of mining activity. Once again, facilities for interchange visits between the officers of different territories would be of value, and could be accomplished with little loss of time by the new air travel. The position of Northern Rhodesia in any co-ordinated system would be complicated by the fact that in this territory geological studies are carried out entirely by the mining companies. Since this grouping was proposed by Sir Thomas Holland, the view has come to be accepted that in any co-ordination of services between neighbouring territories Nyasaland would be more suitably grouped with the Rhodesias.

The geological departments are not as a rule required to raise any proportion of their own revenue. There are exceptions in the case of Tanganyika and Nigeria, where boring for water is undertaken on contract for settlers or for native authorities. Apart from such minor revenue, however, the departments as a rule do much more than pay their way by opening up opportunities for mineral exploitation. Thus in the Gold Coast the discoveries of the small

geological staff since 1913 have led to the annual export of diamonds and manganese to the value of one and three-quarter million pounds (1930), the revenue from which has paid for the upkeep of the department several times over. The story of mineral development in Sierra Leone is even more striking. Until 1926 no minerals of economic value were known in that country, but important deposits of gold, diamonds, iron ore and platinum were discovered by the two government geologists during the years 1926 to 1931. These deposits are already being worked on a large scale and the annual export of minerals was by 1935 nearly three-quarters of a million pounds in value. The direct revenue received by the Sierra Leone Government from diamonds alone in the year 1935 is more than double the cost of the geological and mines department since its formation. Again, the work of the geological department has contributed to raise the value of exports of minerals from Tanganyika to £1,750,000, and the growing revenue from minerals in Uganda has resulted largely from the discoveries of the geological survey. In Nigeria much of the activity of the geologists in recent years has been devoted to water-supply, a service which it is impossible to assess in sterling value, but there can be no doubt that the surveys of underground water carried out there, and the well-sinking operations, will increase prosperity to a marked degree. The department has assisted also in the mineral development.

Northern Rhodesia as a colony has no geological survey, but much good work has been done by the mining companies. The methods differ strikingly from those followed in territories where the mineral rights are vested in the Crown as in most colonies, or are owned by the native holders of the land, as in the Gold Coast Colony and Ashanti, and deserve to be described in some detail.[1] The mineral rights in Northern Rhodesia belong to the British South Africa Company, who have granted exclusive prospecting rights over very large areas to three concession companies under definite terms of obligatory expenditure. Their aim is to search for all occurrences of economic minerals and to develop those deposits that can be worked profitably. In 1929 over ninety geologists

[1] Information supplied by J. Austin Bancroft, Consulting Geologist to the British South Africa Company.

were engaged in this work, and the field staff in 1936 included twenty-two geologists whose efforts were chiefly directed towards traversing, and ten prospectors who were engaged in the trenching of mineral discoveries. In addition, 679 natives were working under the direction of the thirty-two Europeans. The staff is still maintained at about that strength and with its aid the concession areas are being mapped by parallel traverses one quarter of a mile or less apart, between base lines. All rock outcrops are examined and their positions located on the map; all streams are systematically panned, and in areas where streams contain gold, much soil-panning is done and all favourable-looking rocks are crushed and panned. In the course of a year, several thousand samples from occurrences of economic minerals are assayed in the central laboratory. Each month, a progress map on the scale of 2 inches to 1 mile and a brief report is submitted by each member of the field staff, and the data are compiled on map sheets on the scale of 1 inch to 2 miles at headquarters.

To date, more than half the territory has been mapped topographically and geologically, and it is claimed that no portion of the earth's surface of similar area has been more thoroughly searched for occurrences of economic minerals. The development of the copper, manganese, and cobalt deposits are direct results of the activities of these companies. The information obtained is the property of the companies, but topographical data have been supplied freely to the government, and it is hoped that before long copies of the geological map-sheets will also be available for general use.

For the British territories other than South Africa and the Rhodesias, the *Mineral Resources Department of the Imperial Institute* in London serves important functions in supplying information and other assistance in relation to the marketing of minerals, the commercial valuation of oils and similar subjects. Such an arrangement will be indispensable until the individual departments have either grown much larger or have been amalgamated so that ample specialist work is provided for in Africa, and until special officers are appointed to keep in touch with the markets in Europe, as has been done in South Africa and Tanganyika.

FRENCH

There is a headquarters at the Ministry of Colonies in Paris under the organization of the Inspecteur-général des Travaux Publiques. Monsieur Hubert is the scientific and technical advisor. A similar central headquarters for the French African colonies exists in Madagascar. In addition, information is centralized in the *Bureau d'Études Géologiques et Minières pour les Colonies Françaises* in Paris, under the direction of Monsieur Blondel, who at the same time is collating information from all sources for an international geological map of Africa (see p. 71). This bureau has published a series of volumes on the geology and mineral resources of the French colonies, including full bibliographies. That for 1932 contains a number of articles by specialists on individual colonies, surveying the geology and the mining activity at that time. Volumes published in 1933–5 have special reference to all the known mineral deposits of importance; and the series was supplemented in 1934 with a volume on general aspects of the mining industries.

In each of the three major political divisions, French West Africa, Equatorial Africa and the Cameroons, there is a geological and a mining department as sections of the large public works organization. The system adopted in French West Africa, where the department is the most fully organized, will serve to indicate the scheme of work. The headquarters are at Dakar, where there are offices and laboratories for chemistry, petrology, and palæontology. A staff of eleven geologists, of whom two or three specialize in palæontology and the rest in petrology, is maintained. Eight of these spend seven months each year during the dry season working in the field, and return to Dakar to work up their results in the wet season. The total area as far north as the 17th parallel, which coincides roughly with the southern border of the Sahara Desert, is to be covered by 171 map sheets on the scale of 1:200,000, each showing an area of 11,000 square kilometres. Each field geologist can work out one such sheet during the year, so it is hoped that the whole survey will be complete in twenty-two years. Each geologist traverses his area in diagonals, eight kilometres apart. The total cost is about 100,000 francs per sheet.

In addition to this big programme of geological mapping, surveys of underground water have been made for parts of Mauritania

and Niger colony. For advice on sinking wells there are three French mining engineers attached to the department.

BELGIAN

In the Congo there is no official geological department in the usual sense, but a permanent mapping commission under Dr. Fourmarier, with sub-commissions on subsidiary branches such as petrology, meets in Brussels every month. Field workers are sent to areas from which information is required and a valuable framework of geological knowledge is being built up. When the commission was first established it was composed of eminent geologists in Europe, most of whom had not been to Africa, and who only met occasionally. Now, however, it is composed mainly of geologists who have worked in Africa for the mining companies or for the Comité Spécial du Katanga, and who have placed their results at the disposal of the Government. It is expected that the commission's task of making a geological map of the whole Congo on the scale of 1:500,000 will be completed in a few years' time. It is a matter of debate whether this system of sending out experts for short-term work, which the Congo adopts in other subjects besides geology, is as satisfactory as the organization of a settled geological survey department. British authorities generally consider that the settled survey produces more solid results.

In the Congo most of the purely economic geology is carried out by three large mining companies, the Union Minière, Forminière (Société internationale forestière et minière du Congo), and Compagnie Minière des Grand Lacs (Société des Mines d'Or de Kilo-moto), each of which has a special geological department established in the Congo itself. In addition, financial concerns such as the Banque de Bruxelles and Crédit Général du Congo have staffs of geologists and mining experts who frequently go into the field. The *Comité Spécial du Katanga* has a permanent geological department in Africa as well as geologists in Brussels, who visit Katanga from time to time. The programme of intensive mapping has already been mentioned on page 52.

PORTUGUESE

Angola and Mozambique have geological departments as sec-

tions of the large public works departments; these functioned from about 1921–31, when the personnel was much reduced on account of budget difficulties in the depression. The area administered by the Mozambique Company has its own mining and geological section, and a geologist is permanently attached to the staff of the geographical mission in the Tete District, mentioned in Chapter II. Geologists attached to the Portuguese colonies spend four or five months of each year, during the African rainy season, in Europe, for the purpose of working up the results of field work. Portuguese Guinea and St. Tomé have no geological department, but work has been carried out there by special missions.

INTERNATIONAL

For purposes of international co-operation in geological studies throughout the world, congresses are held from time to time. That of 1929 in South Africa was the occasion for international discussion of many subjects bearing on the African continent, and the published volumes (Congress 1930) include many valuable contributions, the sections devoted to pre-pleistocene glacial periods, the Karroo and rift valleys, being of leading importance. The *Internationaler Geologen und Mineralogen Kalender* (1937-) contains, amongst other useful information, a list of the geologists who are now engaged in study in all parts of Africa.

RESULTS

MAPPING

It has been recognized for many years that a geological map of the whole of Africa on a uniform scale was urgently required for general reference purposes, and all territorial maps were sent to the late Dr. J. W. Evans to be incorporated. Little came of the project, however, until the International Geological Congress in South Africa in 1929, when the preparation of an international map was put in hand. M. Emmanuel de Margerie was appointed general secretary of the Special Commission for this purpose, and M. Blondel accepted the responsibility for most of the work entailed. A list of all existing maps from which the international map will be compiled has now been prepared, together with an index

sheet showing the areas for which data are available. The merits of the individual surveys vary considerably, but data sufficent for mapping on the scale of 1:5,000,000 are available for the whole continent, with the sole exceptions of the Rio de Oro and Kenya. The international map itself will cover the whole continent in nine sheets and is now in course of publication.

The International Geological Congress of 1929 also appointed a Sub-Commission of African Geological Surveys, comprising the Directors of the Geological Surveys concerned. This sub-commission met in 1931, and as a result published an International Geological Map of Southern Equatorial Africa on the scale of 1:5,000,000. These international maps include full references to all previous maps of special areas which have been used in compilation, so it is unnecessary to go into details here; but certain particular mapping activities deserve notice.

In the Union of South Africa the mapping programme has been accelerated recently, especially in areas which are of potential mineral value. In addition to a 1:1,000,000 map of the whole Union, the geological department has published large-scale maps at approximately 1 inch to the mile of the principal mineral-bearing areas; and there are also twenty-one sheet maps on a scale of 1:148,750, and five sheet maps on a scale of 1:238,000 (now discarded). All these publications are accompanied by the necessary explanations.

Geological maps of the territories have been published in recent reports of the geological departments in Uganda and Tanganyika, and some important areas have been mapped in considerable detail; for instance the Uganda Geological Survey has issued maps on scales of from 1 to 3 miles to the inch for the Ankole tin-fields (Combe and Groves 1932), the Bufumbira volcanic region and parts of the eastern province. In the Gold Coast, regional geology has been worked out perhaps in greater detail than in the other British colonies, partly owing to its small area and to the relatively larger staff that it has been able to maintain. A revised geological map (1:1,500,000) of the whole colony and protectorate was prepared for the Gold Coast Atlas (1935), and the southern section is covered by a more detailed published map on a scale of 1:500,000.

The programme of wide and rapid mapping in French West Africa and the Belgian Congo has already been mentioned. The series of 1:500,000 sheets of the Belgian Congo will cover the whole area in about fifty sheets, a number of which have already been published. Each sheet is accompanied by a descriptive leaflet. The detailed geological maps of the Katanga on 1:200,000 have also been mentioned before. For the French territories and adjoining regions the atlas of the French colonies contains some of the best co-ordinated geological maps (Grandidier 1933).

PUBLICATIONS

It is impossible to touch in a small space on the numerous other results of the individual departments, but some idea of the available literature may be given before passing on to a brief survey of the known mineral resources and then to a discussion of geological problems in relation to water.

In the first place an industrious and brilliant German geologist has succeeded in writing a systematic geology of the whole continent (Krenkel 1925–8). There are also several notable books on the regional geology of big sections of the continent, especially those by du Toit (1926) for South Africa, Gregory (1921) for East Africa, with particular reference to the rift valleys, and Lemoine (1913) for West Africa.

The British Geological Survey Departments publish summaries of progress, usually in the form of annual reports, while the results of special research work are generally published in bulletins, occasional papers, etc. In Nigeria, in addition to the annual reports, the results of research are published in bulletins, occasional papers and pamphlets. Sixteen bulletins have appeared, covering various subjects from tin-fields, coal-fields, and water-supply, to eocene fish and mollusca. There are also six occasional papers, including such subjects as coal, district geology, and fossils. Of the pamphlets, only one is published. In addition, an important report on the goldfields appeared in 1935 as a sessional paper of the Legislative Council. These publications contain a mass of important information, but the difficulty of following up specific subjects tends to discourage experts from making use of it.

The Gold Coast Department produces annual reports (since 1913), bulletins (six to date), and memoirs (four to date). Tanganyika has annual reports (8vo. since 1928), bulletins (eight), and short papers (twelve).

Uganda has a series of annual reports (since 1925), occasional papers, and memoirs. Two of the latter, on South-West Ankole, by Combe and Groves (1932), and the volcanic area of Bufumbira by Combe and Simmons (1933), may be singled out as examples of the detailed regional surveys now in progress. In 1931, the Director published a most valuable summary of the progress of the Geological Survey from its inception in 1919 to 1929. In 1934 the annual report was reduced to a twelve-page document containing necessary references to the movements of the staff, finance, etc., with the minimum of technical and scientific data, and a series of annual bulletins was inaugurated for the publication of the latter. This system will eventually be of great assistance to the outside scientist.

In view of the advantages of a uniform system of publications, the following scheme, based on a combination of the most valuable methods at present in use, is suggested:

(1) Annual Reports (8vo.) reduced to a minimum and containing only information concerning staff, finance, etc., required by the Government in question or by the Colonial Office.

(2) Annual Bulletins (small 4to.) containing articles on the results of research by members of the department, sometimes articles by outside authorities who have visited the territory, etc.

(3) Memoirs (small 4to.) published as required, each consisting of an individual piece of work which is too long or too detailed for inclusion in the annual bulletins.

(4) Maps.

An attractive system is that adopted by the French, of publishing nearly all results of research in the journals of scientific societies in France. The geological service for French West Africa, for instance, has published short annual reports since 1932, each of only fifteen to twenty pages, with a two-page list of references to papers in societies' journals by members of the departmental staff. This method has the advantages of making the results of research

known to a wide scientific public, and having the several contributions checked and sometimes modified by the publication committee of the society in question.

In this connection, it is important that the Sub-Commission of African Surveys, appointed by the International Geological Congress at Pretoria in 1929, is doing much to make known the results of local study. Working on the assumptions that 'many important publications never reach all the geologists who could draw some profit from them' and that the results of many field reconnaissances remain unpublished, the sub-commission publishes annual summaries of work and references to publications for French West and Equatorial Africa, Angola, the Belgian Congo, and British colonial territories (*Chronique des Mines Coloniales* 1933 onwards). The secretary of the sub-commission is J. Lombard of the Services des Mines, Brazzaville.

HYDROLOGY AND WATER-SUPPLY

Water is of prime importance in all tropical lands which suffer from pronounced dry seasons, since agriculture and most other branches of human endeavour depend upon it. Indeed it is often claimed that water is the most important of Africa's mineral resources.

Unfortunately very little is known about even the major rivers, with the exception of the Nile and its tributaries, certain South African rivers, the Middle Niger, and the Senegal, where irrigation schemes have been put into effect. The dependence of the native population upon water for their villages, their crops, stock, and fishing, calls for the record and classification of streams as perennial, intermittent and so forth. The variation of these characters over considerable periods will give valuable indications of such phenomena as weather cycles and the effect of the destruction of vegetation. Another question which calls for research is the position of the water table in relation to soils and to vegetation cover, whether natural or modified by agriculture. In places where the water table is near the surface regular observation, of the type requiring little training, could produce fruitful results. Water table surveys such as those inaugurated recently in parts of India

should certainly be started when funds become available, as well as the study of subterranean reservoirs.

Even for the Nile Valley there are certain important gaps in our knowledge, especially concerning part of the Lake Plateau basin, the Upper Blue Nile, and the valleys of the Sobat and Bahr-el-Ghazal. But a mass of data has been accumulated since scientific irrigation was introduced and has been made available by Drs. H. E. Hurst and P. Phillips (1931–3).

Knowledge of hydrology for irrigation purposes demands data on altitudes of an order of precision which can only be attained by precise levelling. This branch of survey has been applied in Africa in a few parts of the major river valleys only, and in connection with railway construction. Elsewhere heights have in many cases been fixed by vertical angles, and are therefore subject to considerable error. For the Nile Basin the extent of levelling is shown by Hurst and Phillips (1933, vol.3, plate 1): lines of levelling of first order precision have been carried out from Alexandria upstream to Wadi Halfa, and again from Khartoum up the White Nile to the Murchison Falls above Lake Albert and up the Blue Nile as far as Roseires. The intermediate stretch between Wadi Halfa and Khartoum, including the main series of cataracts, has been levelled with less precision, and so has a line from the Murchison Falls to Entebbe on Lake Victoria. In connection with the proposed scheme for a barrage below Lake Albert and an artificial water-course to shortcut the sudd area, another line of first order levelling has been carried from Malakal on the White Nile, up the Sobat River and thence across country to rejoin the White Nile above the sudd area.

In territories where development has reached an advanced stage, special irrigation departments have been found necessary. This is the case in the Union of South Africa, Southern Rhodesia, and the Anglo-Egyptian Sudan. In most of the colonial territories water-supplies are supervised by the geological departments, and prospecting for water absorbs a considerable part of their resources. In some territories the sinking of wells or bore-holes is undertaken extensively by the geological departments, while in others these activities are carried out by the public works engineers. In several of the colonial territories it is felt that greater knowledge and con-

trol of water-supplies is necessary. This may entail the formation of independent departments which would probably take charge later of irrigation works.

More work has been done in *South Africa* than in other territories, but farmers in many areas may still have to spend several hundred pounds in sinking useless borings before discovering a suitable site for a permanent well. In *Southern Rhodesia*, the geological and agricultural departments and the irrigation engineers have paid special attention to water-supply, and the water situation there is comparatively well known.

For *Northern Rhodesia* there is little published information, but the government has recently initiated water-boring for the relief of dry areas. The geological department of *Nyasaland* has been particularly active. Dr. Frank Dixey, Director of the Geological Survey, has written a valuable book on water-supply (1931), which has special reference to African conditions. Chapter VI on water-finding methods, is particularly instructive, and the last chapter summarizes the water-supply conditions of southern, central, and eastern Africa. References are given there to the more important publications on the subject for the special areas.

Tangan̈yika has a special water-drilling branch attached to the geological department which has been at work steadily since 1931. With regard to water surveys and the action required to make better supplies available, Mr. C. Gillman, Chief Engineer of the Railways, has been particularly interested. In collaboration with Dr. E. O. Teale, formerly Director of the Geological Survey, he made a survey of the whole water question in the Northern Province, and their report (1935) is based on a detailed background of geographical setting, including geological structure, relief, climate, soils, vegetation, population, and economic development. In his geographical studies on population, Gillman (1936) again emphasizes the importance of water-supply in Tangangyika.

In *Uganda*, where a drilling branch was added to the geological department in 1921, extensive work has been carried out, especially in Karamoja, where the water problem is most acute in view of the arid nature of the land and the increase in population. Up to now a hydro-geological survey of that area has not been

attempted, but Mr. E. J. Wayland, Director of the department, is pressing for such a study, as an essential basis for the drilling and well-sinking programme. Wayland and his staff have contributed much data concerning hydrology in other parts of Uganda, particularly in relation to changes towards drier conditions which have taken place in recent geological times, and the possibility of these being continued into the future. This subject, and also the hydrology of the great lakes of eastern Africa, is intimately related to meteorological conditions, and the question whether precipitation and evaporation are subject to cyclical changes. These matters are considered in Chapter IV.

In *Kenya*, this branch of work has been impeded by the concentration of the geological staff on minerals. A. Beeby Thompson (1929) has discussed the water problems facing the colony and H. L. Sikes (1934) has given an account of the known facts regarding underground water resources. Scientific surveys of underground water are badly needed in native reserves and especially in the more or less arid country in the Northern Frontier and Turkana provinces. Since 1928 the public works department has had a dozen or more power drills in operation, and the extension of this service is expected to open up large areas of land now almost valueless through lack of water. It is becoming realized in Kenya, moreover, that many parts of the native reserves lie in poorly watered country where if possible river irrigation would be a benefit. This was stressed by the reports of the Carter Land Commission and of the Tana River Expedition of 1934. In the latter, Messrs. Harris and Sampson (1935) surveyed the possibilities and conclude tentatively that the irrigation of the flood valley itself is out of the question, but a case seems to exist for an irrigation canal in the upper Tana valley. It is significant that, in view of the inadequacy of existing maps, no definite conclusion can be reached until a satisfactory land survey, as well as a soil survey, has been made.[1]

In *British Somaliland* water-boring operations were started in 1930 under a grant by the Colonial Development Fund with the object of opening up grazing areas which at present can be used only for a short time during the rainy season, and discovering

[1] See above, Chapter ii.

underground supplies near the centres of civil and military administration. The work closed down in 1931, after a certain measure of success, but was started again in 1935, with a new scheme, under which several centres of population and grazing areas have been supplied satisfactorily.

Turning to West Africa, the greater part of geological activity in *Nigeria* is devoted to water-supply, especially in the Northern Provinces. Surveys of underground water have been carried out along the northern frontier in the region where it is alleged that the Sahara Desert is advancing. Since 1927, when, after a period of dry years, attention was focused on the water problem in Sokoto, geological investigations have been carried out in that province, and also in Bornu and Hadejira Emirates. It is concluded provisionally that right along the northern frontier of Nigeria water can always be tapped at depths from one hundred to one hundred and fifty feet. Since it occurs in sub-artesian basins, the water is generally under pressure and usually rises to the level of ground water. The deepest shaft constructed measures three hundred and seventy feet, while the highest pressure rise recorded is one hundred and nineteen feet, although there are several of over one hundred feet. By the end of 1935, seven hundred and ninety-three wells had been completed. The work of sinking is financed almost entirely by the various native administrations to the extent of about £18,000 per year, but the cost of all geological investigations and of the administration of the work is borne by the government. The department now advises on all water-supply projects, whatever their nature and scope, and controls and carries out all work connected with sub-surface supplies. In the Southern Provinces a power-driven drill is now at work at Otta, twenty-three miles from Lagos. A scheme for open wells has been approved also for Owerri Province, where permanent running streams are so widely spaced and the population pressure is so great that serious water shortage occurs during the dry season in spite of an annual rainfall of one hundred inches. Full details of investigations on Nigeria's water-supply are given in recent annual reports of the geological department, and in addition Beeby Thompson (1933) has discussed the water problems as a whole, while the geology and water-supply of parts of the Northern

Territories are dealt with by Raeburn and Brynmor Jones (1934) in their volumes on the Chad basin.

The question of water-supply in the north of the *Gold Coast* has not yet been investigated, except during a preliminary survey of conditions by Mr. Cooper, one of the government geologists. The conditions there are in some ways similar to those of northern Nigeria, since the agricultural progress of a large population is held back for want of water. It is interesting to note that the veterinary department at Pong-Tamale has opened up several *billigers* or water reservoirs used by a former native civilization in the northern Gold Coast. These are caverns hollowed out in impervious strata below a hard layer of laterite concretions, a few feet thick, at ground level. During the rainy seasons the caverns are flooded, and the water can be drawn upon for domestic purposes and for stock. *Billigers* are known over a large area, and, though entirely disused and choked with earth and debris, their renovation may contribute materially to the welfare of cattle-owning peoples in that district.

In French West Africa the public works department, with advice from geologists, has worked steadily at well-sinking, in the Sudan and Niger colonies along the southern border of the Sahara. Moreover, the great irrigation developments on the Middle Niger at Macina and Sotuba have necessitated a full organization for hydrographic studies, and the Office du Niger maintains a staff of experts. M. Bélime, the Director of the office, has published (1928) a short account of early work on the Middle Niger. For the past ten years or so the levels and flow of the Middle Niger have been fully recorded as a preliminary to the great engineering works now in progress, but the results have not yet been published.

In other parts of French West Africa, E. de Martonne (1928) made a study of the upper Gambia, and more recently A. Minot (1934) and others have studied the Senegal River in detail with a view to irrigation schemes. Colonel Tilho, whose work is referred to in Chapter IV, has also contributed much data on the hydrology of the Niger, Senegal, and Lake Chad basins, and he has shown how several of the major water-courses in this part of Africa have been profoundly changed in recent geological times. It is

interesting to note also that an hydrographic survey of French Equatorial Africa has been organized.

Of importance in all the regions bordering the Sahara is a method of determining the depth of water in arid country developed by Dr. J. Ball (1927 and 1933), Director of the Egyptian Desert Survey, working in the Libyan Desert. Dr. Ball was able to determine a regular slope of the static water level from the hills near the Mediterranean coast-line southwards into the desert. He mapped the slope of the water level by the use of depth 'contour lines', and wells sunk at selected points found water at the predicted depths. In 1932 K. S. Sandford (1935a) applied similar methods to the south and south-west, in French, Italian, and Sudan territory. He was able to continue Ball's contour mapping of the water level with a few minor alterations. It would appear that this method of establishing the depth of underground water has possibilities in many of the arid parts of Africa, though obviously it would not apply to granite rocks and some other geological formations where the water usually occurs in pockets.

For many years G. W. Grabham, Director of the Geological Survey of the Anglo-Egyptian Sudan, has interested himself deeply in the water-supplies of that country. He has published several papers on the subject, as well as a recent general work (1935), which should be of value in many African territories.

Concerning developments for *hydro-electric power*, although there are many waterfalls scattered through Africa they have been used remarkably little, chiefly because the falls are distant from industrial regions or towns. It was stated in *Nature*, 1930, that the total hydro-electric power generated in Africa is scarcely equal to the production of a first-class steam power station in England. Since then, however, the Tanganyika Government has completed negotiations for harnessing the Pangani Falls, the power from which, it is estimated, could be made sufficient to supply the whole of the territory. Suggestions were put forward a long time ago for using the Victoria Falls for this purpose, but so far only a small hydro-electric plant is in operation there, which supplies the neighbouring town of Livingstone. There are water-power stations in Northern Rhodesia in connection with the copper-mining industry, and in Katanga the Cornet Falls on the

Lufira River have been harnessed and develop 45,000 h.p. In the large mining areas in the southern part of Africa the proximity of coal-fields makes water-power unnecessary. In Uganda, a scheme is being considered for using the Ripon and Owen Falls to supply electricity to Jinja, Kampala, Entebbe and possibly the Kakamega Goldfields.

GEOPHYSICAL PROSPECTING

Geophysical prospecting has been developed only in recent years and its value is still a matter of controversy. Much more fundamental research is certainly required in order to determine the physical and geological conditions under which indications on the instruments are obtained, and particularly where electrical methods are used, the relation of rock conductivities to the amount and kind of the fluid content of the various kinds of rocks; nevertheless it may be claimed that fundamental research has reached a stage which warrants a thorough examination of its possibilities in Africa, especially for the location of underground water in arid regions.

Interest in geophysical work has been widely aroused as a result of extensive testing of methods in Australia in 1928–30, under the joint auspices of the Australian Government and the Empire Marketing Board. Mr. A. Broughton Edge, one of the best-known exponents, was in charge of the investigations, and the report (1932) is an illuminating document.

Methods of geophysical prospecting (Broughton Edge 1932), which of course are not all suitable for the same purpose, are divided into 1. Magnetic, 2. Gravimetric, 3. Electrical: (a) Surface potential, and (b) Electro-magnetic, and 4. Seismic. The gravimetric method requires very expensive apparatus (torsion balances) and a high degree of skill. The seismic method, which depends on making explosions at the surface and measuring the time for the percussion to be reflected off subterranean bodies and recorded by seismometers at various distances, is also expensive. The magnetic and electrical methods are much cheaper and are generally of wider application. They are discussed in some detail in relation to the finding of ground water, with the aid of numerous diagrams, by Bruckshaw and Dixey (1934).

These methods have been used by commercial companies for the location of mineral deposits and petroleum-bearing rocks. Government departments will be primarily interested in their use for the detection of underground water-supplies. For this purpose the electrical method is most suitable.

The electrical or 'resistivity' method depends on the principle that strata saturated will conduct electricity better than dry strata. Therefore, by applying an electric field to the ground and measuring the potential at various points, the degree of resistivity of underlying rocks can be measured and the depth and extent of water can be estimated. Depths from two hundred and fifty to five hundred feet are usually given for the effectiveness of the electrical method for locating minerals. These figures do not apply in the case of water, however, for under favourable conditions it is claimed that the depths and extent of water-bearing formations can be determined down to one thousand feet or more. The Australian work has shown that under suitable conditions the presence of saline water can be detected; this would have great practical value in obviating the risk of sinking wells only to find that the resulting water is useless for either stock or irrigation. It must be stressed that only trained geologists can produce satisfactory results, as the interpretation of any geophysical observations involves a full understanding of the rocks.

It seems desirable that this method of locating supplies should have extended trials with as little delay as possible. The necessary instruments can now be purchased for £200 or even less, so experiments need not prove too expensive. Interest has already been aroused in parts of Africa and some work fully worthy of consideration has been carried out. In South Africa, the Geological Survey of the Union is pursuing investigations into the value of various geophysical methods of prospecting for minerals and for underground water, the work being done by trained geologists. In addition, there are a number of experts of varying qualification, who work on contract for mining companies, for the purpose of discovering valuable mineral resources.

In Southern Rhodesia Mr. Shaw (1934), working on underground water, has made investigations which were checked by bore-holes. The drillings confirmed the indications from resistivity

measurements in a very satisfactory way. Since the cost of operating the resistivity method is negligible compared with that of drilling, it is concluded that the savings from its use must be very large. Mr. Shaw emphasizes that the success of the method in locating underground water depends largely on the geological interpretation of the electrical evidence by which the formations, supposed to carry and yield water, may be discovered. Following Mr. Shaw's work, the Irrigation Department of Southern Rhodesia has carried out further electrical surveys for water, with most encouraging results.

The Department of Geophysics at Cambridge and a few other centres have been actively pursuing geophysical research for many years, but the facilities for training in the application of the methods were restricted until the recent establishment of a School of Applied Geophysics at the Imperial College of Science and Technology in London. The geological departments of the Gold Coast, Tanganyika, and Nyasaland, however, have already sent members to London for periods of training.

In Nigeria, where a member of the department, Dr. Tatham, has studied the subject at the Colorado School of Mines, electrical prospecting for water has been going on for several years. This method has been used in Ijaw, Katsina and Owerri, and the last-named province, where a programme of well-sinking based on the geophysical survey has been put in hand, will provide a good opportunity of testing the results of the electrical method. In the Gold Coast, three members of the staff have received some training in London, and experiments are being carried out to ascertain the value of electrical methods as applied to local problems. Magnetic methods will also receive attention as soon as the necessary instruments can be acquired.

It is needless to devote much space to the merits of the divining-rod and pendulum, which are believed by some exponents to be capable of detecting not only water but also minerals and a variety of other objects. There are scientific men who have put the methods to the test and conclude that the successful diviner finds water by a process of conscious or sub-conscious appreciation of topography and geology, and that the activity of the actual rod is purely incidental and of no significance; others hold that the diviner is a

super-sensitive individual interpreting some unrecognized hygroscopic sense, and still others deny the possibility of divining on general scientific principles. Divining is still employed in many parts of Africa where European settlement and farming are well established, but it has caused considerable disappointment and waste of money. It is an occupation which allows ample scope for charlatans, and the fact that the majority of diviners are ready to ply their trade for absurdly small pay leads one to regard it with suspicion. In addition to the human diviner, there are certain instruments on the market with the same object in view. These have been tested by scientists in several parts of Africa and in other parts of the world, without success. The need to base methods of water- and mineral-finding on irrefutable scientific principles is an added reason for an increased study of geology and geophysics.

GEOPHYSICS AND PALÆONTOLOGY

There are certain other aspects of geology and geophysics which it is easiest to regard as pure rather than applied science, but which, nevertheless, have indirect bearing on development. In geophysics there are the subjects of seismology, vulcanology, gravity, and terrestial magnetism, each of which has received some attention in parts of Africa. In geology there is the vast subject of palæontology of which one branch deals with the interpretation of stratigraphy and the age of rocks, and the rest is concerned more with understanding the evolution of organisms, including man. In this Africa has already made very important contributions to knowledge. This array of subjects merits at least a book in itself, but a few points only are selected for mention below.

Seismology is the recording and interpretation of earth movements, and has been studied to a small extent. Seismographs are installed and under continual observation at six places in Africa; namely at Cairo, Dakar (maintained by the Meteorological Service established in 1931), Lomé in French Togoland, Accra in the Gold Coast, Capetown, and Johannesburg. At Entebbe in Uganda seismometers are also installed, but since 1931 observations have had to be suspended owing to lack of staff. This was the only observation centre in the very important region of the rift valleys

where earth movements occur at frequent intervals, and served as the only link in the records between Cairo and the Cape. During 1930 and 1931 two seismometers were working at Entebbe, oriented at right angles to one another. Two epicentres for the numerous local shocks of Uganda were discovered, one in the Ruwenzori Mountains and one at the north-west end of Lake Albert. This branch of research has its practical application, since the Fort Hall earthquake of 1928 was a fairly serious matter, and a somewhat stronger shock from this epicentre might damage buildings in both Kenya and Uganda.

The *variation in gravity* over different parts of the earth's surface has received attention from geophysicists in connection with the structure of the earth. In Africa it is interesting chiefly in the region of the rift valleys. Previous to the war, observations were made in Tanganyika by the Germans, and in 1933–4 Dr. E. C. Bullard, from Cambridge, made a special expedition to the rifts of Kenya and Uganda. A summary of his results is published by the geological department of Uganda (Bullard 1935), and E. J. Wayland remarks in his preface that the work is a valuable contribution to the controversy with regard to the nature and origin of rift valleys. Its significance is more than academic, for it has certain bearings on the petroleum-winning possibilities of the Albertine depression. The full results of this investigation have been published by Bullard (1936), and on the same subject the veteran American geologist, Bailey Willis, who visited East Africa recently, has written an important book (1936). This work, which is discussed by Simmons (1937), consists of two main parts, the first giving the general picture and the second detailing characters of the several areas. An hypothesis is advanced for the formation of the whole plateau of eastern Africa and of the rift valleys. The measurement of gravity, if carried out more or less evenly over the whole surface of the earth, would lead to practical results in another way. Numerous determinations would enable the true form of mean sea-level to be computed with reference to an adopted mathematical figure. If this form were known, then astronomical determinations of latitude and longitude could be used with confidence for the control of certain classes of survey.

Passing to the subject of *Palæontology*, it may be fairly stated that

Africa presents a boundless field of research. Already it has supplied important evidence on the history of evolution; in particular, mention may be made of the Transvaal Museum and the researches of its Director, Dr. R. Broom, during the past thirty-five years, on the fossil reptiles of the Karroo. In his book (1932) Dr. Broom remarks (p. 309): 'If any intensive collecting is done in the next twenty or fifty years we shall know not three hundred and fifty species of South African fossil reptiles, but 20,000 to 50,000 species, and we may then not only be able to trace the lines of evolution, but perhaps be able to see what has been the guiding or compelling force behind it all.' Farther north, the rich beds of fossil reptiles in Nyasaland and southern Tanganyika have attracted several collecting expeditions from the British Museum, Cambridge University, and elsewhere. The results have contributed greatly to knowledge of the diversity of reptilian life in the mesozoic era, and to that important link in the chain of vertebrate ancestry when reptiles were changing into mammals.

The study of fossils leads up to the origin of man and the geological contribution which Africa has already made to knowledge, and the important discoveries made by Professor R. Dart, Dr. R. Broom, Dr. L. S. B. Leakey, and others are outlined in Chapter XVIII. The study of ancient man has involved that of stone tools, which are widely used in working out the stratigraphy of recent geological deposits. This in itself may have practical bearings: for instance, Wayland's work on stone tools in Uganda demonstrated the reversal of some of the principal rivers, a result which has been of great importance to those prospecting for alluvial tin.

Man's history, stone tools, changes in hydrology, tectonics of rift valleys, aquatic fauna and numerous other subjects apparently of academic interest, all contribute to the understanding of the late geological history of Africa, of pluvial periods and arid periods. Understanding of these is of importance in appreciating conditions of aridity in the future, when climatic change may yet take place. Many such problems are concentrated in the region of the great lakes, and the geological survey of Uganda has paid special attention to them (Wayland 1933–4, 1934a, 1934b and 1935, Groves 1932). The subject is considered further in Chapter IV.

CHAPTER IV

METEOROLOGY[1]

INTRODUCTION

THE modern development of air communications, from Europe through Egypt or down the Red Sea to East Africa, and across the Sahara or down the Atlantic coast-line to West Africa, necessitates a close degree of co-operation between the meteorological services of countries bordering the Mediterranean with those lying to the south of the Sahara. This chapter accordingly includes the Mediterranean countries in its purview.

The principal applications of meteorology to human progress are two: the utilization of climatic conditions and the prevision of weather changes. The agricultural capacity of different areas depends largely on climatic conditions; water-supply, navigation and the development of hydro-electric works depend in different ways on the variation of rainfall. Weather forecasts of relatively long periods are valuable for the farmer and for the traveller, who wants to know what roads will be open; and daily forecasts, supported by more frequent warnings of sudden change, are essential for the purposes of air transport.

The major industry of Africa—farming—is often seriously handicapped by weather, especially by variation in rainfall, and experience of past disasters has shown the need for data collected over long periods of years at numerous stations. Meteorological records have been somewhat unsystematic in the past, and this is still true for some areas, where rainfall is measured by African clerks. In a

[1] Arrangements were made in 1934 for a specialist, Mr. L. C. W. Bonacina of the Royal Geographical Society, to prepare a separate memorandum on Meteorology in Africa. This has been most valuable in writing the following summary of the subject, but it has been supplemented by other information, and the draft has been completely revised after comments and criticisms were received from twenty-five specialists who are referred to in the Preface.

very few regions recording stations are unnecessarily close together, but in most they are still too far apart, and international co-operation is difficult to organize when, as in some of the British territories, the collection of data is the duty in one of the agricultural department, in another of the survey department, in others of administrative or medical departments.

For the development of airways climatological observations require to be supplemented by observations of visibility, height and amount of low cloud, direction and velocity of upper winds obtained by pilot balloons, and, if possible, temperature in the free air as recorded by aeroplanes and registering balloons.

The development of engineering works raises another aspect of the application of meteorology. In certain areas regions of extremely high rainfall are not very far removed from arid regions where water is required for the supply of towns or for irrigation. The time may come when the value of the products of intensive cultivation might justify the expense of collecting mountain rainfall in reservoirs for transference in canals or pipes to arid regions nearby.

For agricultural purposes the form in which rainfall data are presented is of importance. In comparing different parts of Africa it is usual to deal with the annual rainfall, or sometimes the monthly rainfall, but experience is showing that even the monthly unit is too large, and that ten days is the longest unit of real agricultural value for research. Since the year cannot be divided into ten-day periods, the pentad (five days) might prove a more satisfactory unit. In a year divided in this way, February 29th would be included with the appropriate pentad to make a six-day period once in four years. Whatever the unit selected, a uniform method of presentation over the widest possible area is desirable, this might be based on the five-day unit, and give figures for each unit's total rainfall and for the number of days of rain in each unit. In making such a suggestion it is presumed that the daily readings would be permanently available for research purposes in the several meteorological offices. The wet and dry seasons of those regions in which the year falls into two periods of contrasted rainfall should also be studied as units, though of varying duration. In many places the study of evaporation from water and land surfaces is also important.

The collection of the data required for the development of air services necessitates a high degree of organization, especially in transmitting daily weather reports by wireless, and such organization must be international. Uniformity such as will make comparison possible is of extreme importance and must be sought through the collaboration of meteorological officers in the different territories. A detailed statement from each territory describing the present methods employed and suggesting the lines on which uniformity could be achieved would contribute greatly towards this end. Full data would be required for each territory on the number of first order, second order, and rainfall stations compared with the area and type of country; the type and accuracy of instruments used and the method of exposing them, i.e. screening of thermometers, height of rim of rain-gauges above the ground, etc.; and the detail given in weather forecasts and warnings. It is worthy of note that in 1936 there met for the first time at Lusaka, Regional Commission No. 1 of the Office Météorologique Internationale; subsequent meetings of this and other similar commissions should be of the greatest assistance in achieving uniformity and the rapid exchange of data.

Of meteorological literature, A. Knox's book on the climate of Africa (1911) is a landmark, but other authors must be consulted for the results of more recent studies. Notable among recent works are papers by Dr. C. E. P. Brooks on the British colonies, while the report of the South African Drought Commission of 1923 is a most important document in showing the relation of rainfall to other subjects such as deforestation, soil erosion, and the subsidiary changes which those processes involve (Kanthack 1930). Important general works which have appeared since Knox's book are given in the bibliography—notably Brooks and Mirrlees (1932), Cox (1935), Eckardt (1917), Geiger and Zierl (1931), Sir Henry Lyons (1917), and Shantz and Marbut (1923). The standard modern reference work is the volume on Africa in the *Handbuch der Klimatologie* edited by W. Köppen and R. Geiger (1927).

In view of the stimulus which meteorology has received in recent years from the establishment of air transport, and the probability that co-operation between adjacent services is likely to take place along the lines of air routes, those which already exist and

some which are proposed are mentioned in the following note:

Air Routes

The *British* Imperial Airways main route from Cairo follows roughly the course of the Nile via Khartoum and Malakal to Kampala and Kisumu on Lake Victoria, thence eastward to Mombasa, along the coast to Dar-es-Salaam, Mozambique, Beira, Lourenço Marques and Durban. Wilson Airways run a branch service from Kisumu to Nairobi, and thence two services, one via Mombasa, Tanga, and Zanzibar to Dar-es-Salaam, the other via Moshi, Dodoma, Mbega, Mpika to Broken Hill, and Lusaka. Another branch service connecting Bulawayo, Salisbury, and Blantyre with Imperial Airways at Beira is run by Rhodesian and Nyasaland Airways. Early in 1937 Imperial Airways discontinued their service from London to the Rand, and opened their flying boat service down the east coast to Durban. Imperial Airways opened a branch service from Khartoum via Fort Lamy to Kano in 1935, which was continued to Lagos in 1936. It was extended along the Guinea Coast to Accra in 1937 by Elders Colonial Airways and is to be extended to Takoradi in the Gold Coast. South African Airways, controlled by the Union Government, run services from the Rand via Kimberley to Windhoek, the Rand to Kisumu, the Rand via Bloemfontein to Port Elizabeth, the Rand to Durban, the Rand to Capetown, Capetown to Durban along the coast, and the Rand to Lourenço Marques.

The *French* central African services operated by Air Afrique alternate with the *Belgian* Sabena services in providing a trans-Saharan crossing, either via Algiers, El Golea, and Aoulef, or Oran and Regan, to Gao, and from thence eastwards to Niamey, Zinder, Fort Lamy, Fort Archambault, and Bangui. Here one route runs westwards via Coquilhatville to Brazzaville. The other runs south-east via Stanleyville and Elisabethville, where it is continued by the Madagascar Government service via Broken Hill to Quelimane and Mozambique on the coast, and thence to Madagascar. The west African service, operated by Air France only with flying boats, runs along the coast from Casablanca to Dakar, thereby connecting with the transatlantic service. From Dakar the Aeromaritime service continues the coastal route to Pointe

Noire, touching at the French ports of the Gulf of Guinea and at Monrovia. A branch line from Niamey runs through Dahomey to the coast.

The *Belgian* service, Sabena, besides the main trans-Saharan crossing in which they alternate with the French service, run internal services connecting Brazzaville (Leopoldville) with Boma and Matadi on the west, and eastwards with Port Franqui, Luluaborg, and Lusambe. Another internal service connects Brazzaville, Coquilhatville, Lisala, Basakoto, and Stanleyville.

In *Portuguese* East Africa, the D.E.T.A. Portuguese Government service runs from Lourenço Marques to Johannesburg in connection with the Imperial Airways service along the east coast. In Angola a projected line runs from Humpala via Loanda to Kabinda in the Belgian Congo.

The *Italian* air line, Ala Littoria, connects directly with Rome, Benghazi, Melita, Tunis, Tripoli on the Mediterranean coast; and there has recently been established a regular route to the colonies of the East Coast, running via Cairo and Khartoum to Asmara, Assab, and Jibuti. These three are all directly connected to Dire Dawa, as are Addis Ababa on the west and Mogadishu on the east coast.

The *German* line by sea-plane runs down the West Coast to Bathurst in the Gambia, and thence across the Atlantic to South America.

The *Dutch* line to the Far East crosses the north-east corner of the continent from Tobruk in Libya, via Cairo to Baghdad.

ORGANIZATION AND RESULTS

At present the four meteorological organizations which cover the greatest area of Africa, but not in all cases the most highly developed, are those of (1) The Union of South Africa; (2) British East Africa; (3) Egypt, which has close relation with the Sudan and to some extent with Abyssinia, and (4) French West and Equatorial Africa. These correspond to the four regions into which it is convenient to divide the continent for meteorological purposes, the South, Central, North-East, and North-West. The first of these regions includes Southern Rhodesia, Mozambique, and

Madagascar, each of which has an independent, active, and efficient meteorological service. Each of the regions will be considered in turn.

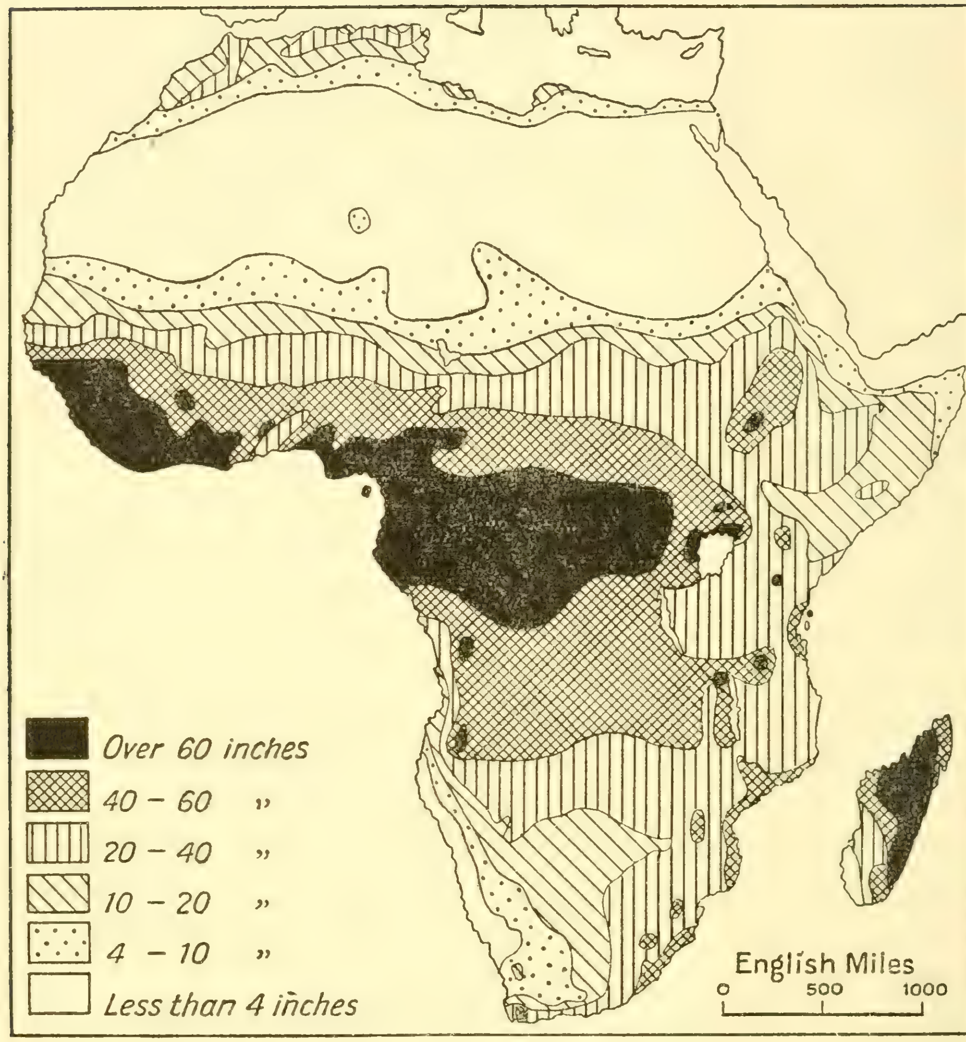
SOUTHERN AFRICA

Since most of this region is under British rule, the establishment of centralized control should not prove difficult. At present the meteorological offices of the Union, Southern Rhodesia, and South-West Africa are independent.

In the *Union of South Africa* the Meteorological Office at Pretoria comes under the Irrigation Department. Data from the Protectorates are also collected and published by the same office.

The service for air transport, comprises six first order stations at Pietersburg, Germiston, Kimberley, Victoria West, Matroosberg, and Capetown, which form a line through the country from approximately north-east to south-west, on the main Imperial Airways route. At these stations continuous records of pressure, temperature, humidity, surface wind direction and velocity (except at Matroosberg), and hourly observations of visibility from 8.30 a.m. to 4.30 p.m. have been made since January 1932. Pilot balloon observations were begun in 1918, and since 1932 have been made at the same six stations several times per day, mostly limited to 10,000 feet to meet the requirements of aviation; at least one per day at each station to the greatest height attainable. The results of pilot balloon observations are given in great detail by Cox (1934). In addition, visibility has been recorded daily at 173 other stations, and the height and quantity of cloud at 55 stations, since August 1932.

There is a full organization for the preparation of daily weather forecasts based on reports from 100 stations in the Union, seven in Southern Rhodesia, one in Northern Rhodesia, six in South-West Africa, and twelve in Madagascar. The forecast is broadcast daily (except on Sundays and holidays) for the benefit of all sections of the community, and for shipping additional broadcasts are made from Mozambique, Lourenço Marques, Durban, Port Elizabeth, and Capetown (Union of South Africa 1934). For aviation, however, these daily weather reports are not sufficiently frequent, in view of the rapid changes to which South African weather is sub-



MAP 1. Mean Annual Rainfall. (*After Fitzgerald, 1934.*)

ject. Weather reports every three hours would be desirable, but since the development of aviation at present does not warrant this, a system of telegraph and wireless communication between meteorological stations has been evolved to provide individually for each flight. For non-scheduled flights the arrangements are not yet satisfactory. Since flights usually begin at an early hour, the issue of weather reports from all stations soon after dawn is being urged. It should be remembered that African circumstances are very different from those of Europe, where numerous aeroplanes are always in transit.

Data on rainfall are more complete for the Union than for any other part of the continent, with the possible exception of Egypt. Rainfall is now recorded at 4,074 stations, including the seventeen in Bechuanaland, thirty in Swaziland, and thirty-one in Basutoland. The official publications on this subject are the annual reports of the Meteorological Office and chapters in the annual handbook; A. D. Lewis (1927), of the Meteorological Office, has analysed all rainfall normals up to the end of 1925. Much material has also been published by the universities and in scientific journals, and reference is made in the bibliography to important papers by J. M. Sim (1917), F. E. Plummer (1926 and 1932), Professor of Geography at Pretoria, J. R. Sutton (1921), Schumann and Thompson (1934) on rainfall; Howard (1920), Spencer (1926), Evelyn (1904), and Schumann (1936) on general climatology; Schönland and Craib (1927) on the electric fields of thunderstorms. In addition to the Meteorological Office and the Universities, the Union Observatory at Johannesburg is a centre of research, and the Director, Mr. Wood, has contributed much to meteorology in South Africa.

A general analysis of the available data has been made by Plummer and Leppan (1927), who point out the practical importance of even minute local variations in determining the competitive advantages of different agricultural areas. Professor Plummer is aiming at procuring accurate standard normals of rainfall over the whole country. It should be noted, however, that stable averages of rainfall, or any element of weather, do not exist in any part of the world. Approximations to averages on a fifty-year period are as much as can profitably be sought.

The study of secular variation of rainfall is carried much further by Schumann and Thompson (1934) who have analysed all useful data in the Union, dividing the territory into thirty-two rainfall districts. By the use of smoothed curves they have revealed more or less pronounced secular variations during the period of about fifty-five years for which records exist. Their conclusions are of great importance in relation to the alleged desiccation of Southern Africa and are considered in detail below.

In the western part of the Cape, there is a section with winter rains, one with summer rains, and one with rain at all seasons. The rainfall (Plummer 1932) is extraordinarily variable not only from year to year, but also from place to place, both the wettest and driest spots in the Union occurring in this province. In the Cape Peninsula great variations in the average rainfall within short distances are brought about by contrasts between the warm water of False Bay and the cold water of the open Atlantic in relation to the prevailing winds and relief of the land. Even within the limits of Capetown District variability is pronounced, though the average rainfall of the city as a whole is about the same as that of London and is just as reliable from year to year. The more northerly parts of the Union, especially the Transvaal (Plummer 1926) and the Orange Free State, are intensely hot in summer and subject to a somewhat unfavourable seasonal régime of rainfall, a large part of it falling in thunderstorms which are probably the worst in the world. Hail is a great scourge, stones varying in size from walnuts to cricket balls being quite common, with deadly effect on livestock.

All parts of the Union which lie at any altitude experience from time to time heavy falls of snow. In Basutoland, where there are extensive tracts of country over 6,000 feet, snow may fall even in summer. During the heat of summer low pressure over the interior of South Africa causes a reinforcement of the moisture-laden south-east trade wind from the Indian Ocean, and where this moist wind strikes the high Drakensberg scarp heavy rain results.

In *South-West Africa* there is an official Meteorological Office at Windhoek created by the German administration. Little work is now undertaken beyond the collection and summarizing of mete-orological data. In this respect a good start was made by the

Germans before the war. Two papers by Range (1915) and Reenen (1925) are valuable. In spite of the aridity due to the absence of considerable rainfall, the climate is somewhat damp by reason of the copious night fogs and dews caused by the cold Benguela current. The provision for aviation appears to be undeveloped; upper air research has been confined to fifteen months' intensive observations with pilot balloons at Walvis Bay (Cox 1934, p. 230), and similar observations are now in progress at Mariental: all these were carried out by the Union meteorological department. Since the air service in this territory is run by Union Airways, this seems to be a case where centralization of meteorological services is desirable.

In *Southern Rhodesia* the official meteorological service is part of the Irrigation Division of the Agricultural Department. The collection of climatic information dates from 1897. There are two first order observatories at Salisbury and Bulawayo, where intensive studies have been made at high altitudes with pilot balloons, and the results have been considered with the South African data by Cox (1934). More than forty other stations, well distributed over the country, observe temperature and pressure in addition to rainfall, and there are about 550 stations for rainfall only. The records are made entirely by Europeans, a system of regular inspection is in force, and the results are published in monthly bulletins and annual reports (the latter since 1900). A system of daily forecasting and the preparation of weather maps has been in operation since 1923 (Robertson 1927; Sellick 1934), and more recently a twice-daily service including upper wind observations for aviation has been established. The radio exchange of synoptic reports is in operation with Northern Rhodesia, Mozambique, Madagascar, and the Union.

A special feature of the service is the preparation of seasonal forecasts according to Sir Gilbert Walker's methods. The prediction of excess or defect in rainfall was published in ten years between 1922 and 1934, and in eight of these the anticipation proved correct. Sir Gilbert Walker (1933) points out that meteorological conditions are more persistent in tropical than in temperate countries, and concludes that prediction is, accordingly, more likely to be successful in the former. Since in southern Africa the upper

levels of hilly country are better for cultivation in wet years, and the lower levels in dry years, the prediction of an abnormally wet or dry year would be of the greatest value to agriculture. It is to be hoped, therefore, that the system adopted in Southern Rhodesia may be extended to other territories. A section on the climate of Southern Rhodesia, prepared in the meteorological office by C. L. Robertson and N. P. Sellick, is included in Köppen and Geiger's great work (1927).

In *Angola* there is an important meteorological and magnetic station at Loanda, but little organization in the hinterland. The literature is not extensive, but two valuable papers by Marquardsen (1917) and Roque (1925–26) are cited in the bibliography.

Mozambique has an official service centred at the Campos Rodrigues Observatory, Lourenço Marques, where upper winds are observed and daily weather charts are plotted. There are three first order stations, all situated on the coast, at Inhambane, Quelimane, and Mozambique, and another at Beira under control of the Mozambique Company. There are a number of second order and rainfall stations, but their distribution inland is somewhat irregular. The annual and monthly reports are models which might well be followed elsewhere. The climate is described in Köppen and Geiger (1927) and by Peres (1931).

Madagascar has an official service and a well-equipped laboratory at Tananarive. Short-term forecasting and the broadcasting of weather reports are highly developed. The island has been studied thoroughly, and practically all that is known about its climate and weather is embodied in the standard work by Poisson (1930). For no country on the mainland of Africa, except Egypt, is there such a complete account. Tropical cyclones and thunderstorms are both formidable manifestations, and are discussed by the author with remarkable acumen. Appendices deal with native weather-lore, and the influence of the moon on barometric pressure and other elements. It is pointed out that Madagascar is exceptionally well situated for the study of minor lunar influences on the atmosphere. This, of course, lends no support to the popular belief that the weather is controlled by the phases of the moon.

CENTRAL AND EAST AFRICA

The meteorological service of *British East Africa* was developed in 1929, principally with a view to the organization of meteorological studies throughout East Central Africa, but also in order to connect under a single organization a series of stations along the Imperial Airways route. This is the reason for the inclusion in the group of Northern Rhodesia, although this territory is affected to a large extent by climatic conditions in areas farther south. The service does not cover Nyasaland. The central office is at Nairobi, where a qualified statistician, Mr. Walter, is in charge of the correlation of all data. £7,000 per annum is contributed toward this service by the Governments of Egypt, Sudan, Zanzibar, and the East African colonies. Egypt contributes the largest share because the highland rainfall controls so much of the Nile's water-supply.

There are five first order stations, at Kampala, Kabete, Tabora, Zanzibar, and Broken Hill. Here hourly values of the meteorological elements are recorded and upper air data are obtained from pilot balloon ascents twice daily. Only a few magnetic, electric, and solar radiation data are collected, but further magnetic results are being obtained with the assistance of the Carnegie Institution of Washington. There are forty-eight second order stations, of which eleven are in Kenya, fifteen in Uganda, twelve in Tanganyika and eight in Northern Rhodesia. These stations take full climatological observations twice daily and at three (Dodoma, Mbeya, and Mpika), pilot balloon ascents are made. In addition, 750 rainfall stations record the daily rainfall, and at 160 the temperature is also read. Of these, 310 are in Kenya, 90 in Uganda, 200 in Tanganyika, and 150 in Northern Rhodesia. There appears to be need for a better organized system of wireless communication to promote closer contact between the adjoining British territories and with the foreign colonies, especially the Congo. It is worth noting that the study of daily weather variations in East Africa and also in Rhodesia is rendered difficult by the lack of topographical surveys, because heights of some of the barometric stations are not known with sufficient accuracy.

Before this service was established, each of the territories had its own network of recording stations and the data from separate areas had been analysed by several authorities, especially Brooks (1924)

for Uganda and Kenya, Rodwell Jones (1933) for Kenya, Hurst and Phillips (1933) for all the regions lying within the Nile Basin, Sir Henry Lyons (1917) and Paap (1934) for the former territory of German East Africa (Tanganyika and Ruanda-Urundi). There are still large areas, such as the northern arid regions of Kenya, where information is scanty. The meteorology of these countries is exceptionally interesting on account of the local complexities introduced by such impressive natural features as the rift valleys, the equatorial snow peaks, and the great lakes. The investigations of Dr. Brooks and others on the rainfall of British East Africa show that this is governed to a much greater extent by vertical relief than might perhaps have been expected near the equator where the rains are mostly of the doldrum type without much wind. In England we are accustomed to associate 'orographic' rainfall with the effects of mountain slopes in forcing upwards damp cyclonic winds, condensation resulting from cooling by adiabatic expansion as the air rises into levels of reduced pressure. This effect undoubtedly occurs also in East Africa, as is shown by the considerable precipitation which occurs on the rising ground exposed to the south-east monsoon. But mountains also increase rainfall by hindering the free passage of rain-bearing currents of air, so that rains last longer than in open plains, and also by favouring local thunderstorms. The latter factor is apparently of great importance in the tropics.

Nyasaland has its own service under the Department of Agriculture. Two rainfall maps of the whole territory, for November to April (wet season) and May to November (dry season), have been compiled by Hornby (1935) and the climate of Central Nyasaland has been described by Hornby (1933).

The whole East African region, where meteorology is intimately bound up with hydrology, is of the greatest scientific interest, particularly in relation to the oscillations of climate, as indicated by recent geological history and the change in levels of the great lakes. These subjects are treated later in this chapter.

In the *Belgian Congo*[1] a meteorological service under the Institut Royal Colonial Belge was established in 1911 and reorganized after the war on a somewhat different plan. There are now three first

[1] Information from notes by M. Gasthuys.

order stations under meteorological specialists; two, at Eala and Elisabethville, were established before the war, and a third, at Tshibinda in the Kivu area, was opened in 1928. The station at Elisabethville is the best equipped of the three and controls the meteorological service of Katanga. There are some 300 rain stations, of which 100 also make observations of temperature. All these are in charge of agricultural officers, administrative officers or missions, but, in spite of careful instruction, the temperature observations, in particular, have sometimes been found unsatisfactory. In the Kivu area the rain stations, in addition to that at Tshibinda, were organized by M. Scaëtta, and a remarkable piece of work was the installation of four rain-gauges for high altitude observations on the mountains Buzezu (2,460 metres high), Bugoi (2,230 metres), Kahuzi (3,308 metres), and Karissimbi (4,506 metres). The water collected in these gauges is measured every six months.

Before 1911, some observations were made by administrative officers and missions, but the records in general lack continuity, except one at Banana which continued for twenty years. Important papers on the climate are by Gasthuys (1924) on various regions of the Congo, and by Scaëtta (1933) on the rift valley.

Air services in the Congo are developing rapidly. The distribution of meteorological information by wireless has not yet commenced, but arrangements to effect this service are reported to be in preparation.

NORTH-EAST AFRICA

Egypt, through its dependence on the Nile, has interests in meteorology and hydrology which extend beyond its territorial boundaries, and its Physical Department has undertaken researches over nearly the whole Nile basin, and has established recording stations in the Sudan and in Abyssinia. The connection between Egypt and Great Britain has, further, led to a close co-operation between the meteorological services of the two countries, especially for the development of the Imperial air service.

Much material has been published on the meteorology of Egypt. Hurst and Phillips (1931) have brought together all important data in the first volume of their book on the Nile basin. The

Meteorological Atlas of Egypt (1931) is a handsome production prepared by order of King Fuad I. It gives maps and diagrams of the geographical and seasonal distribution of elements, in some cases for Egypt only, in others for Egypt and the Anglo-Egyptian Sudan, and in others again for the whole of the Nile basin, including the great lakes. The papers by Peters, Sutton, Range, Spath, Lahmeyer, and Dorno, referred to in the bibliography, may be selected as of especial value. In addition, numerous papers have been published in recent years on local Egyptian climatic conditions, including one by B. E. F. Keeling on the climate of Abbassia and one by L. J. Sutton on the climate of Helwan.

It is interesting to note that the network of meteorological stations includes the oases of Siwa, Dakhla, and Kharga in the Libyan Desert. For these it has been considered safe to base normal values on a ten-year record. Even at such almost entirely rainless stations, severe storms occasionally occur, yielding from one to two or more inches of rain within twenty-four hours.

A belief that was held some years ago, that the extensive Nile irrigation works were making Egypt colder and damper, was found to have no basis, although it is quite likely that localized night fogs are now more frequent over the irrigated surfaces.

In the *Anglo-Egyptian Sudan* special study has been made of the northern region near Khartoum where cotton cultivation is developed. The most important paper is by Sutton (1923). A string of stations has been established down the Nile in connection with irrigation works; some of these have been enlarged and additional stations created for the airways. Summaries of the observations made in Egypt and the Sudan are published in the Annual Meteorological Reports issued by the Physical Department, Cairo. They comprise observations from about eighty meteorological stations and a hundred rainfall stations.

British Somaliland has an efficient station at Berbera. There are six other stations in the Protectorate which record particulars of temperature, rainfall, and velocity and direction of ground winds.

Libya maintains an official service with headquarters at Tripoli. A considerable number of meteorological studies have appeared of late years in Italian journals. Eredia has published numerous papers on the meteorology of this and the other Italian colonies

in Africa; that of 1923 is of particular interest because it was at Azizia, an oasis some thirty miles inland from the Mediterranean coast, that there occurred on 13th September 1922 a shade air temperature of 136° F., the highest ever recorded under standard conditions. The work of Fantoli (1930 and 1932) is also important.

In *Eritrea* there is no official service, but climatological stations have been established, and the main features of temperature and rainfall are known. A useful paper by Eredia (1932) discusses the seasonal distribution of rainfall in relation to the physical features of the country. It is shown that the rainfall is heaviest (some forty inches a year) on the eastern plateau slopes, whence it declines to a few inches on the hot Red Sea coast, being there confined to the winter months. On the plateau summit about 7,000 feet above sea-level the rainfall, which comes in summer, is fairly heavy, but lower down, on the western side sloping to the Sudan, it is again scanty.

The late Duke of Abruzzi set up a number of stations in the southern part of *Italian Somaliland*. These have furnished valuable data which have been discussed by Eredia (1927). This territory, though it lies in a latitude normally affected by the equatorial rain-belt, has very scanty rainfall. The explanation is to be sought in the disturbance of the normal equatorial circulation by the Asiatic summer monsoon system. On the west side of Africa, on the other hand, the equatorial rains are reinforced by monsoonal influences.

In *Abyssinia*, there was no weather service up to 1936, apart from the few stations controlled by Egypt. The climate has been studied by three British and Egyptian scientific missions, in connection with the scheme for regulating the outflow of Lake Tana.

NORTH-WEST AFRICA

Tunis, *Algeria*, *and Morocco* (French and Spanish) have official meteorological services and are well supplied with data. In particular, several stations have recently been established in Algeria down the air route across the Sahara. The Institut de Météorologie et de Physique du Globe at Algiers serves as a centralizing base for the French North African territories.

In Tunisia the winter rainfall is quite heavy on the coast but

declines rapidly southward towards the Sahara. The Tell plateau has a continental climate. In spite of intense summer heat, heavy snowstorms occur now and then in winter at 2,000 feet.

For Algeria there are two important papers by Franc (1923) and Prat (1929). The second is of special interest in showing the beneficial influence of fog-moisture in rainless regions. On the south side of the Murdjadjo range, which faces the scorching winds of the Sahara desert, there is no vegetation on the lower slopes, but a xerophilous type flourishes precisely down to the level reached by heavy nocturnal mountain mists. The northern flank of the range comes under the influence of heavier rainfall and is forested.

For Morocco three important papers are those of Bernard (1922), Wattier (1926), and Russo (1931). The Moroccan littoral is rather cool for its latitude, subject to copious night dew and mist, as well as a liberal winter rainfall. In the interior the rainfall diminishes and the summer heat is severe at low levels, but great local complexity of climate results from the influence of the Atlas range. Although one or two peaks actually reach the limit of perennial snow, it may be said of the Great Atlas as a whole that at 12,000 feet it just manages to clear itself of snow for a short time in summer —much in the same way as the Scottish Grampians do at 4,000 feet in a much colder latitude. But there is indisputable geological evidence that during the pluvial epoch, which was contemporaneous with the pleistocene ice age in Europe, the Atlas mountains bore powerful glaciers.

The meteorological services of *French West* and *Equatorial Africa*[1] and the *French Cameroons* were reorganized in April 1929 and have developed noticeably since that date. Each of these administrative areas has now an efficient independent service, centralized and correlated by a special department of the Ministry for Colonies in Paris under M. Hubert. The service in West Africa, under M. L. Welter, was established in 1931. There are nineteen principal stations, each in charge of a qualified meteorologist, where observations are made on the ground and in the upper air with pilot balloons, on temperature, pressure, humidity and wind velocity, some of these being observed hourly and others

[1] It is convenient to include French Equatorial Africa in this group for reasons of its organisation, although it really belongs to the Central climatic region.

three-hourly. Data from each of the principal stations is transmitted twice daily to the central office at Dakar, where daily weather maps are prepared and forecasts are broadcast. This system of weather forecasting cannot attain its full significance, however, until corresponding methods are adopted by the surrounding territories. There are, in addition, fifty-eight first class stations, where ground observations are made twice daily, and 141 second class stations for rainfall. Most of the rainfall records were started in 1900–1905, but a few records on the Senegal coast go back for fifty years. The service in Equatorial Africa, which is organized on the same lines, was fully established only in 1935.

The most important publication on this region is the large volume by Hubert (1926) on West Africa, containing all data available at that time, and profusely illustrated with maps and graphs. Many of the results since 1931 are published in the *Annales de Physique du Globe de la France d'Outre Mer*, edited by Hubert and published bimensually. Welter (1930) has compiled a useful list of eighty-five papers and books, of which thirty-five are by Hubert, on the meteorology of French West Africa, while the most recent publication on the subject is by Foissy and others (1937).

Rousseau's paper of 1931 on the rainfall of Senegal is particularly interesting. The distribution of rainfall shows a marked latitudinal or solar control, the average annual quantity ranging from sixty inches in the south to twelve inches in the north. North of Cape Verde cold water keeps the coast arid. The rainy season or 'hivernage' occurs between June and October. The rains follow the two passages of the vertical sun in May and August but are accentuated by a coastal monsoon accompanied by tornados which make August the wettest month. The rainfall is much more uncertain from year to year in the dry north than in the wet south. Welter (1931) has analysed the rainfall of Dakar from records at the railway station from 1887 and at the hospital from 1903. These show a pronounced eleven-year periodicity over four cycles, coinciding with the periodicity in sunspot numbers. In years of greatest solar activity the annual rainfall amounted to 650–700 millimetres, and in years of minimal solar activity it was reduced to 350–450 millimetres. Another long series of records at St. Louis has been analysed by Constantin (1930). Apart from the eleven-year perio-

dicity, there is no evidence that total rainfall has suffered any reduction during the fifty years in which records have been kept.

Two valuable contributions in English on the coastal region are by Gautier (1933) on French Guinea, and Braby (1913) on the harmattan wind.

Meteorological data for the Sahara are by no means numerous, but the new principal stations at Gao, Aquelhock, Tamanrasset, and Regan will provide serial records before long. A notable paper is that of Brooks and Mirrlees (1929) on records made by Francis Rodd whilst travelling in the Sahara, mainly in A'ir during 1922–7. An extreme maximum air temperature of 114° F. was recorded in June, and an extreme minimum, slightly below freezing point, in December. The most interesting data, however, are afforded by the humidity readings. The relative humidity varied between 82 per cent. and 2 per cent., and the absolute humidity or pressure of aqueous vapour between 22 mb. and 1 mb., indicating that while the air of the Sahara desert is at times almost dry, it can at times contain more moisture than is practically ever contained in the air of England. In tropical latitudes the air even in deserts cannot remain dry for any length of time because of the incursion of moist winds from surrounding regions.

In the Cameroons and neighbouring territories, the conspicuous climatic feature is the high rainfall. Here the ordinary equatorial rain-belt is reinforced by the south-west monsoon blowing on to the mass of Mount Cameroon which attains some 13,000 feet above sea-level. Under the German administration a number of private rainfall stations were set up, and an important paper by Semmelhack (1933) on the rainfall of Debundja, one of these stations near the south-western foot of Cameroon Mountain, analyses a forty-year record. It is pointed out that, with an average of 350 inches a year, Debundja is the wettest spot near sea-level so far known in the world, and that in all probability the higher levels of Cameroon Mountain are wetter than the very wet mountain stations in the Khasi Hills of Assam and in Hawaii. As this enormous rainfall is spread over 261 days in the year, the climate is extremely rainy. In 1919, according to Semmelhack, as much as 532 inches fell, compared with *only* 273 in 1909. The greatest fall in 24 hours is 18 inches, but this is not outstanding for

the tropics. Debundja now lies in British mandated territory and an official recording station was established there after the war. The official record for 1919 is still greater—577¼ inches.

In *Nigeria* (with part of the Cameroons) the official service is organized by the Surveyor-general. Since 1935, when the Imperial Airways extension to Kano was opened, two members of the survey department have been seconded entirely for meteorology, and other observers have been trained to take charge of the six major stations which are planned for the use of aircraft. In addition to these there are some sixty-five stations distributed throughout the country, but most of them are poorly equipped and can supply data on only a few of the meteorological elements. Where survey offices exist, the data are collected by the survey staff, but for the most part the observations are in charge of district officers and medical officers, and may be left to African subordinates. Hence many of the observations are not reliable, though improvement has been effected in recent years by extensive correspondence regarding discrepancies in the data submitted. British West Africa as a whole is one of the few quarters of the habitable globe where data on pressure systems are not available, but this state of affairs will be remedied in Nigeria by the new principal stations. Comparatively few of the existing stations are situated in the dry parts of the Northern Provinces, where data on rainfall are important in connection with agriculture, forestry, etc.

Concerning publications, Brooks (1920a and 1920b) has written two papers on the distribution of temperature and the distribution of relative humidity. There is a great difference between the Southern Provinces which have in places a very heavy rainfall, and the Northern which are under Saharan influences, particularly during the season of the dry harmattan wind from the north-east.

H. N. Thompson (1928), when Director of Forests, reported on the irregularities of rainfall in Nigeria over a period of twenty years. The object was to ascertain the extent of association, if any, between the irregularity of rainfall and the alleged desiccation, especially in the regions bordering the Sahara. No definite conclusions could be reached, except regarding the best ways of ensuring future water-supplies by preserving natural vegetation, especially along streams and water-divides (see Chapter VII).

Nigeria took an active part in the Polar Year observations of 1932–3, and the results have been printed in a special publication (Nigeria 1934) which includes data obtained at eight selected stations. In 1933 the Survey Department published two rainfall and wind maps, for November to April (dry season), and April to May (wet season). A particular feature of the Southern Provinces is the short dry season in July and August, which divides the rainy season into two. This is of great importance to agriculturalists in that it allows two crops to be raised during the year; it has never been satisfactorily explained by meteorologists.

In the *Gold Coast* meteorological services are divided between the Agricultural and Survey Departments. The former is responsible for ninety-three observation stations for rainfall and some of these record also temperature, pressure, humidity, and winds. Some trouble has arisen concerning the records of temperature, in that thermometers have shown remarkable diversity of performance after a few years' work in the Gold Coast climate.

A map of annual rainfall is published every year for the Gold Coast, and in 1930 a rainfall chart was prepared for the whole of West Africa, including French territory (West Africa 1930). The climate has been described in the bulletins of the agricultural department by the Director of Agriculture, G. G. Auchinleck (1926a and 1926b) and by N. P. Chamney (1928). An important problem with regard to rainfall is concerned with the effect of the escarpment in Ashanti. This ridge of high land, running across the territory from north-west to south-east, appears to control precipitation, and hence coincides with the limit of forest land and cultivation of cocoa. Observation centres for rainfall north of the escarpment are, however, very few, so that the rainfall map can be regarded as only approximate. The heavy precipitation on the coast near Axim remains unexplained, but it has been suggested that the moisture-laden winds from the Gulf of Guinea travel north-east as far as the escarpment, where they rise, precipitate part of their moisture and return towards the south-west to precipitate most of their rain near the coast.

The meteorological work necessitated by the extension of the air route from Nigeria has been placed under the survey department. Two complete stations are established, at Accra and Tak-

oradi, for recording pressure, winds, etc., at ground level and in the upper air with pilot balloons. A difficulty in selecting the best sites for aerodromes arises in that the direction of prevailing winds at the coast is not known adequately.

The survey department has been in charge of observations relating to tides, which are important in connection with the port of Takoradi, since this harbour was built. The division of meteorology into two sections administered by different departments is somewhat unsatisfactory. It is anticipated, however, that with the further development of airways, it will be necessary to establish a unified meteorological service in all the British territories of West Africa.

Sierra Leone has an official meteorological service as part of the Department of Agriculture, organized on the same lines as that of the Gold Coast. There are eleven stations for rainfall, dating back sixteen years, except that at Freetown, which has a fifty-six-year record. The climate has been described by Brooks (1922). As no British air routes to Sierra Leone are contemplated at present, the need for fully equipped meteorological stations has not yet arisen.

In the *Gambia* meteorological work is in charge of the Colonial Secretary, and published records are scanty. There are two rainfall stations, at Bathurst and Georgetown, with records of about twenty-six years. The annual rainfall is some forty inches.

Portuguese Guinea has no official service and information is not readily available.

For *Rio Muni* and *Fernando Po* information is wholly lacking beyond references in general works. The rainfall is generally very heavy, particularly in the mountainous island of Fernando Po.

Rio de Oro. This Spanish territory is climatically part of the Sahara, but nothing appears to be available in print concerning its meteorological development. The interior, towards or beyond the Mauretanian border, is difficult of access in consequence of the hostile attitude of the Moorish tribes.

In *Liberia* there is no regular meteorological service, but the climate has been described by H. J. Coolidge (1930).

ATMOSPHERIC CIRCULATION

Special reference must be made to the circulation of the atmosphere in view of its importance for understanding local variation in weather and for forecasting. Since Africa is bisected by the equator it is in a symmetrical position in relation to the equatorial rain-belt. This is flanked by sub-tropical belts of high pressure, dominated by the trade winds. In the north the trade wind desert belt stretches from the Atlantic to the Red Sea, but in the south desert conditions are confined to the Atlantic Coast, because the Drakensberg scarp obstructs the passage of the moisture-laden trades from the warmer Indian Ocean, and induces abundant rainfall. The extreme north and south of Africa are influenced by the westerly cyclonic belt during the winter months, and enjoy higher rainfall.

Two factors, however, alter this symmetry of climate: the greater width of North Africa, which causes the actual thermal equator to deviate northward because in tropical latitudes the land is warmer than the sea, and the greater height of South Africa (average of 4,000 feet above sea-level, compared with 1,000 feet in the north), which increases this asymmetrical effect.

It is in analysing the influence of these factors on the climate that the recording of atmospheric circulation has the greatest interest. Since the war studies have been made by Lyons (1917) on North Africa, by Brooks and Mirrlees (1932) for Central Africa, and by Cox (1935) for South Africa. The authors have considered conditions in the upper air as well as at sea-level, making use of modern methods of upper air research. Thus Sir Henry Lyons shows that the south-west monsoon or surface air-current of the Guinea Coast has a vertical thickness of not more than 5,000 feet, being overlain by the north-east harmattan. Mr. Cox points out that the South African plateaux interfere so much with the surface circulation that at some places, such as Durban, the wind often blows in complete opposition to the barometric gradient. In summer apparently the south-east trade, which brings much rain to the Drakensberg scarp, does not succeed to any great extent in passing over the range into the Transvaal, but is deflected and reaches that country from the north and passes out to sea in Natal from the

north-west. In winter the cold of the high veld raises the pressure sufficiently to cause something of an outflowing monsoon, weakening the south-east trade. Dr. Brooks and Mr. Mirrlees relate the distribution of rainfall in tropical Africa in each month of the year to the main stream-lines of the circulation. Rain falls: (1) along the line of separation or 'front' between currents of different physical quality, as between the humid south-west monsoon and the dry harmattan of the Guinea Coast; (2) where two or more stream-lines converge, as in the case of northerly and southerly trade winds meeting in the equatorial rain-belt; (3) where humid winds meet or converge upon mountains, as in the Cameroons and Abyssinia.

A great contrast exists between West and East Africa in the equatorial belt. In West Africa the equatorial rains are enormously enhanced in their northern summer migration by the moist south-west monsoon which interacts with dry winds from the north. In East Africa, on the other hand, the local circulation is entirely dominated by the centre of low pressure on the Persian Gulf. This prevents the indraught of any moisture-laden monsoon, or any convergence of air-currents over Italian Somaliland, where the equatorial rains are almost entirely suppressed.

The encircling equatorial rain-belt, which moves northward and southward with the vertical sun, may be regarded as the mainspring of the atmospheric circulation in the sense that its position and intensity help to actuate the other wind and pressure belts of the earth's surface. It is likely to be specially sensitive to any periodic fluctuations in the output of solar energy. In view of the probability that Abyssinia receives the whole of its summer rain, which supplies the autumn Nile flood, from winds blowing ultimately from the Gulf of Guinea, there is great need for meteorological stations capable of taking pilot balloon observations, in the north part of the Belgian Congo and the south-west part of the Anglo-Egyptian Sudan.

CHANGES OF CLIMATE

It is now well established that a pluvial epoch occurred in Africa at about the same time as the glacial epoch in Europe, and that

while the British Isles were buried under ice, the Sahara was in large measure green, populous, and fertile. At the same time the snow-line on the equatorial mountains was much lower than at present, the drainage systems were strikingly different, and the equatorial lakes were very much larger than now. Furthermore, it has been shown, especially in eastern Africa, by the work of Wayland (1935), Leakey (1931 and 1935), and Nilsson (1935), that the pluvial epoch was not a continuous time of intensive rains and snows, but was divided into a series of pluvial periods separated by arid interpluvials when the climate was much drier than it is to-day. The importance of these arid periods, especially in relation to past and present fauna, has been stressed by Fuchs (1934) and Worthington (1933).

A question of significance for the study of changes in climate throughout the world, is whether the series of pluvial periods in Africa were contemporaneous with the series of glacial and interglacial periods in the northern hemisphere. This question is not yet settled. It has been discussed by several authorities, notably by Brooks (1931). Whether the desiccation that has since overtaken the Sahara and affected all equatorial Africa is yet completed on the geological time scale, we have no definite means of knowing, but several experts are of the opinion that Africa is even now emerging from the last pluvial period, and is still undergoing a steady change to drier conditions, though not without oscillations and temporary damp phases. Wayland and Leakey in particular reach this conclusion from their studies of prehistoric climates in Uganda and Kenya. On the other hand, J. D. Falconer (1911 and 1937), who has discussed the geological evidence for climatic change in Northern Nigeria, concludes that the desert pulsates with an expansion and contraction of its margins and that the most recent movement has been one of contraction, with the consequent spread of more humid conditions over the country between Lake Chad and the River Niger. This question is further discussed in the next section.

Turning to changes in climate on a smaller scale, which may be recognizable in the records collected since the European came to Africa, there is also a considerable literature, some of which is referred to in a valuable paper, devoted mainly to the European

climate, by A. J. Brunt (1937). The fact that annual changes of climate are more regular in tropical regions, especially over large continents, renders Africa peculiarly favourable for the study of cyclical variations, but unfortunately there are few records which extend back to fifty years or over. The well-known Brückner cycles, with a periodicity of about thirty-five years, covering three eleven-year cycles of sunspots, have been traced back in Europe through several centuries. It appears, however, that 'generally speaking the Brückner cycles characterize the higher latitudes while the eleven-year cycle (i.e. one cycle of sunspots) is more strongly expressed in equatorial regions.' Wayland (1935, p. 106).

According to some authorities the sunspot cycle is felt with particular intensity in the East African region, where meteorology is intimately bound up with hydrology. During the years of sunspot minimum, solar radiation and hence evaporation are greatest and rainfall is less than the average. This is reflected in the rise and fall of the levels of the great lakes which offer enormous areas for evaporation. The years of highest level have been roughly, 1895, 1906, 1917, 1927–8, and the next is predicted for about 1939. Dr. Brooks (1923) has shown that the levels of Lakes Victoria and Albert rise and fall with a periodicity of about eleven years, the lakes being high at sunspot maximum. He argues that, although the rainfall over these basins is higher at sunspot maximum, the correlation between lake levels and rainfall is much weaker than that between lake levels and sunspot. Hence he concludes that the physical explanation is to be sought in increased evaporation at sunspot minimum, which is in keeping with the known fact that the mean temperature in equatorial regions is about one degree F. higher at sunspot minimum.

A similar response to solar activity is disclosed by Dr. Dixey's (1924 and 1927) researches into the level of Lake Nyasa, but the relation here has been complicated by the blocking of the outlet via the Shiré river, which since 1920 led to a continuous rise in lake level. The levels of Lake Tanganyika since 1912 have been made available by Gillman (1933), who shows that they too follow the eleven-year cycle closely. His paper includes a series of graphs bringing the data for Lakes Victoria, Albert, and Nyasa up to 1931, but he adds a note of warning against premature generaliza-

tions in view of the fact that in 1930 and 1931, when the sunspots were nearing their minimum, the levels of all the lakes rose in an unexpected manner when they should have been falling.

It is important to note that some authorities do not believe that a connection between the lake levels and sunspots has yet been proved, particularly in view of the unexpected developments of the last few years. Dr. H. E. Hurst, Director of the Physical Department in Egypt, for instance, who has paid particular attention to the effect on the variation in level of Lakes Victoria and Albert on the flow of the Nile, points out that Brooks' correlation co-efficient of 0·83 between the level of Lake Victoria and sunspot numbers for the period 1896–1922, has fallen in the period 1923–1934 to 0·06, and for the whole period 1896–1934 to 0·60 which is scarcely significant. Furthermore, he shows mathematically that there should be a difference of a quarter of a period, two and a half to three years, between the maximum sunspot numbers and the maximum lake level, whereas Brooks found these coincident. For these reasons Dr. Hurst regards the correlation between lake levels and sunspots as a chance relation which has now disappeared.

If it can be concluded in general that the recent abnormal rise of the great lakes is a temporary variation from a permanent cycle, then we should expect that records of rainfall over long periods in other parts of the continent would show similar cyclic variations. The fifty-year record at Dakar, according to Welter (1930), shows a striking correspondence with sunspot numbers (see page 105), but appears to be the only case; Schumann and Thompson (1934) in their study of South African rainfall conclude that 'cycles of fixed periodicity are not in evidence in South African rainfall. If cycles do exist, they are more or less completely masked by the much more prominent irregular secular variations.' They are dealing, however, with a part of Africa where conditions are those of temperate rather than tropical latitudes.

It is interesting to consider the effect of these periodic changes on biological cycles and even cycles of human activity, though here we are mainly in the realm of speculation. It has been suggested that the eleven-year cycle influences plant growth and so the incidence of locust invasions. Simmons (1929) has pointed out the striking fact that the periods of food shortage in Uganda,

especially in 1898, 1908, 1918–19, and 1928, appear to be similarly periodic, and are essentially due to failure of the short rains in the preceding year.

Though the relation between rainfall, lake levels, and sunspots might seem to be of academic interest, these examples suggest that full understanding of climatic cycles in Africa may eventually lead to long-range weather forecasting of sufficient accuracy to be of real economic value.

ALLEGED PROGRESSIVE DESICCATION

Some authorities believe that the whole continent of Africa is affected by a progressive desiccation, which is said to have been accelerated in recent years. There is an extensive literature on the subject, particularly in relation to West and South Africa. Colonel Tilho is the authority for the Chad Basin, and M. Hubert for the Senegal region. The late Professor Schwarz discussed the problem as affecting Africa as a whole, but it should be noted that some of his conclusions have been discredited as a result of more recent work. The evidence strongly suggests that large tracts of Africa are drying up, through a combination of influences, geographical, meteorological, and human.

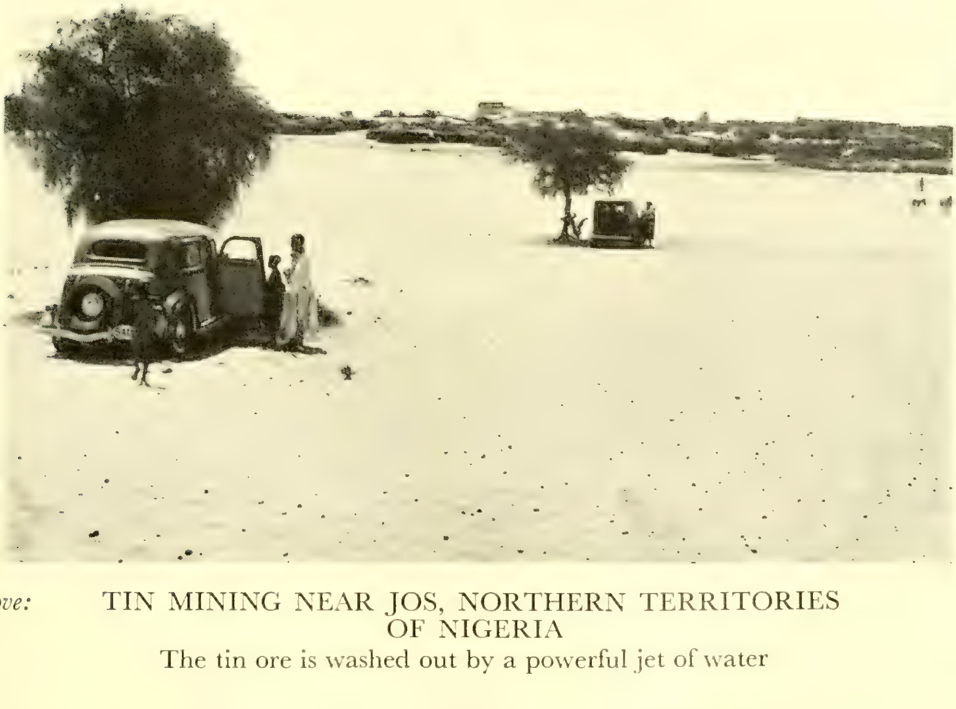
The chief geographical factor is river-capture, though the silting up of streams and lakes and the movement of sand dunes have also played their part. Schwarz (1921) laid great stress on the unfavourable topography of Africa, which is such as to give rise to steady head-stream erosion by short coastal rivers, resulting in the capture of water which formerly drained the interior of the continent. He considered this the fundamental cause of the disappearance of Lake Ngami in the Kalahari, and of the dwindling of Lake Chad, as well as of a great diminution in the volume of the Niger in modern times. He suggested also that the ultimate fate of Lake Victoria will be capture by an affluent stream of Lake Tanganyika, which is cutting back the low watershed to the south-west of Lake Victoria. A thorough examination of the area, however, has shown that this cannot happen for many thousands, if not millions, of years. Colonel Tilho (1928) fears that Lake Chad may disappear through the capture of the Logone and ultimately of the

Shari by the Benue River, unless the process can be thwarted by engineering works.

Schwarz's well-known scheme (1923) for making a lake in the Kalahari Desert by restoring water to the Okavango drainage system which is now tapped by the Kunene, has been found impracticable by engineers, but the possibility of forming great artificial lakes in Africa in order to create cultivable land and sources of hydro-electric power has been discussed more recently by H. Soergel of Munich (1936). He suggests that a great dam two and a half miles long about 500 miles from the mouth of the Congo would turn the basin into an inland sea with an area of about 350,000 square miles. An outlet by the lower Congo would provide abundant water power, or, alternatively, an outlet could be arranged to the north to create a second inland sea centring on Lake Chad. A further suggestion is for a dam on the Zambesi River above the Victoria Falls in order to create an inland sea over much of the Kalahari Desert. These suggestions are mentioned here merely in order to indicate how the physiography of Africa might favour change at some future date.

Apart from such comparatively rapid change as that produced by river capture, the Sahara appears to be noticeably extending southwards, especially in the Chad region and along the border of northern Nigeria. Wells are said to be drying up, villages have been deserted and a general southerly movement of population has been noticed. All this evidence has been put on record and discussed by several authors, notably Hubert (1920), Bovill (1921), and Mangeot (1932).

More recently Professor Stebbing (1935), after travelling through the area, concluded that the only way to arrest the advance of the desert is to establish a great belt of protected forest along its southern boundary. Other experts, however, deny that the Saharan advance is really a menace to civilization in that area. The members of the geological department of Nigeria, for instance, who carried out the surveys of water resources mentioned in Chapter III, do not accept Professor Stebbing's evidence as conclusive. Dr. Raeburn (1928) concluded that this region, like the rest of Africa, has undoubtedly undergone a process of desiccation in the remote past since the pluvial periods, but 'whether this regional



Above: TIN MINING NEAR JOS, NORTHERN TERRITORIES OF NIGERIA

The tin ore is washed out by a powerful jet of water

Below: THE ADVANCING SAHARA AT TIMBUCTU

In historic times this land was fertile, but to-day sand-dunes are entering the city

desiccation is in progress in Nigeria at present is unproved and demands the closest scientific investigation before the fact can be accepted.' The real criterion must lie in records of rainfall, but these cover so short a period of years in the area in question, that they contribute no evidence. Whether or not the desert is advancing as a whole, all are agreed that the effect of man has been very serious in this danger zone, and that the establishment of forest 'shelter belts' would be of great advantage. This subject is considered in connection with forestry in Chapter VII.

Some authorities are inclined to attribute the apparent desiccation to the cyclical changes of climate discussed on page 113. In French West Africa for instance, where the eleven-year cycle is so evident in the rainfall records of Dakar, M. Welter considers that the population tends to move southward during the years of reduced rainfall, but does not subsequently return to the north.

As regards the meteorological evidence, careful examination of long rainfall records fails to reveal much sign of diminished precipitation in recent years. The best data are from South Africa, given by Schumann and Thompson (1934). Their conclusions are so important that a few points are quoted: '3. The greater part of the Union enjoyed a period of plentiful rains around the year 1890. This possibly accounts for the popular idea that South Africa is drying up. 6. Over the last forty to fifty years the annual rainfall in certain parts of South Africa shows a more or less definite, though irregular downward trend. There is no proof, however, of any permanent diminution, and periods of plentiful rains may confidently be expected in the future. 9. The depopulation of the Midland Districts, to which attention is drawn by the Drought Investigation Commission (1923), appears to be fundamentally attributable to the downward trend of the rainfall in this area over the last forty to fifty years.' There is a widespread belief in the drought-stricken regions that reckless deforestation and burning of grassland have tended to make a larger percentage of the rain come in destructive storms instead of in well-distributed gentle downpours.

The principal human activities concerned in the process are the destruction of forests and natural vegetation in association with unenlightened methods of farming. Studies of the influence of

forests on rainfall have led to inconclusive results. Deforestation probably does not diminish the actual annual rainfall, but it nevertheless produces drought. When forest cover is removed the rainwater, instead of percolating slowly into the soil and draining gently into the rivers, tends to flow away rapidly and violently, causing soil erosion and temporarily extensive flooding. Eventually large tracts of country, which were formerly well watered, become arid.[1]

Whether or not Africa, as a whole or in part, is undergoing progressive desiccation, one conclusion seems certain: the drought-stricken parts of Africa are in no position to meet a possible prolonged cycle of drier years. If these came, all the various factors of drought here mentioned would, unless countered, be intensified in a vicious circle of interacting effects that might cause extensive depopulation.

BIOCLIMATOLOGY

The word bioclimatology is used to describe the general study of the effects of climate on life. One aspect of bioclimatology is concerned with the 'ecoclimate', or the meteorological conditions occurring in a particular limited environment, such as a bush or cubic metre of atmosphere overlying soil. Such variations are often of a surprisingly large order; hence the objection to the previously used term 'micro-climate' with its implication of minute variations. In reality any climate is made up of a number of ecoclimates, and large-scale representations are merely approximations of value in comparing one area with another, or tracing the differences associated with seasons. From the biological point of view, moreover, the changes in climate from hour to hour and from day to day are often of as much importance as seasonal changes.

The study of ecoclimates has scarcely yet come into prominence in Africa, but the work accomplished shows to how great an extent insects and other organisms may depend on slight changes in

[1] The subjects touched on here are treated in more detail as follows:—Influence of forests and other vegetation on rainfall in Chapters vi and vii, pp. 161, 178, etc.; soil erosion in Chapter v, p 136.

meteorological conditions. In relation to tsetse flies and other insect pests, the study promises most fruitful results.

The first detailed studies of ecoclimates in Africa were made by J. Phillips at Knysna in the Union. In 1928 a series of similar studies were started by the Department of Tsetse Research in Tanganyika, and some results have been published in papers on the ecology of tsetse flies, referred to in Chapter X. Since 1931, ecoclimatic studies have been in progress at the Botanical Department of the Witwatersrand University, in connection with veld studies, and the ecological research on pastures of South Africa inaugurated by Dr. Pole Evans has necessitated further studies which are now in progress.

T. W. Kirkpatrick (1935), of Amani Research Station, finds that 'in most respects the climatic conditions in a coffee plantation differ widely from those that obtain in a standard meteorological screen, and not always in the direction that might on first thoughts have been anticipated'. As an example, the temperature of the outer leaves of a coffee bush may fall in some cases to as much as 7° C. below the minimum recorded in the meteorological screen. Thus coffee may suffer from the direct effect of freezing, even where no frost has ever been officially recorded. Many other deviations from the standard climate, of a magnitude that undoubtedly exercises a great influence on the fauna of a coffee plantation, have been recorded, and some of these are susceptible to at least partial control.

For biological purposes the study of evaporation is particularly important in connection with the problem of soil erosion and in estimating the effects of forests and other vegetation on rainfall and run-off. Even in South Africa data are very scanty, and for evaporation rates the old free-surface evaporimeter is still in official use. In 1923 at the Forest Research Station of Knysna, J. F. V. Phillips introduced Livingston atmometers of various kinds. These have proved to be greatly superior to the free-surface evaporimeter, and they have subsequently been used in Tanganyika and elsewhere.

The various potentialities of land can only be fully understood with knowledge of evaporation rates. It is largely through their effects on plant life that climatic changes such as the possible desiccation of Africa affect human beings. Hence the need has

been felt for some index of the amount of water available for plants at different times and places. Various indices have been suggested for this purpose. R. Lang in 1915 proposed a 'rain factor' depending on precipitation and temperature; in 1926 de Martonne proposed and used as an 'indice d'aridité', precipitation (in millimetres) divided by temperature (in degrees Centigrade plus 10); both of these may be criticized in that temperature is not the sole factor controlling evaporation, since humidity and wind-rate are also very important. A. Meyer in 1926 suggested precipitation divided by saturation-deficit, but this could only be used in places where records of humidity are taken frequently, or are obtainable from recording instruments. A better index, where the evaporation rate is obtainable, is precipitation divided by evaporation, a ratio which is considered fully by Livingston and Shreve (1921). A similar index is proposed and used for French West Africa by R. Portères (1934). He terms this the 'indice de sécheresse' which is 'hauteur d'eau en mm. au moment ou nous percevrons sur A (i.e. the plant in question) le seuil de sécheresse'.

Rates of evaporation are also relevant to hydrological studies, particularly in the region of the great lakes, on most of which evaporation from the surface is nearly equal to or even greater than the sum of rainfall on their surfaces and the water received from affluent rivers. Some uniform system for recording evaporation is therefore a matter of importance.

METEOROLOGY AND MEDICINE

Meteorological studies are relevant to medical work from two points of view. The first is concerned with the effects of climate on such animals as mosquitoes, tsetse flies, and ticks, which convey disease. These are the effects which are normally implied in the expressions 'good climate' and 'bad climate' in the tropics. In this branch of the subject, known as insect ecology, numerous special studies are being made, showing how closely the carriers of disease depend on relatively minute changes in their meteorological environment, especially perhaps on humidity.

Secondly, there are the direct effects of meteorological conditions on the human system; about these relatively little is known, even

in the case of the European climate. It seems probable that uniformly high temperature is a factor adverse to health and occasional changes to a cooler climate, either at a hill station or in temperate latitudes, are desirable for Europeans working in the hotter parts of Africa. The adverse effects of high temperature are greatly intensified when it is associated with high relative humidity, as the latter greatly reduces the cooling power of moving air. In desert climates the surprising paradox is found that during the hot dry season there is often actually more moisture in the atmosphere than is normal for Great Britain, but the drying effect of the air is very much greater on account of higher temperature. This has been pointed out by C. E. P. Brooks (1932) and by L. J. Sutton (1923). On the other hand the moisture content of desert air can fall much lower than in temperate climates, and on occasions may be reduced to almost nothing on account of the complete lack of evaporating surface over vast areas. Under these circumstances the desiccating power of desert winds becomes terrible.

Biologically, light and direct radiation as elements of climate may be fully as important as temperature, moisture, and wind, but this is not always realized, and knowledge of radiation, especially in the tropics, is very scanty. Lately Sir Napier Shaw has drawn attention to this defect in meteorological descriptions. It is significant that medical science has not yet decided what kind of radiation is responsible for the sunstroke from which Europeans so frequently suffer in tropical Africa; some attribute this to ultra-violet radiation, others to infra-red. The first published account of light intensity in the tropics in terms of photochemical units appears to be that of Phillips, Scott, and Moggridge (1931). Working in Tanganyika for a year with an Eder-Hecht photometer, they found the light intensity (measured in Bunsen-Roscoe units) to be very high, even in the absence of direct sunlight, and this appears to indicate that the unpleasant effects of tropical sunlight on cloudy days result from radiations of short wavelength. In South Africa some preliminary work has been done on the ultra-violet content of sunlight by Osborn and Raftery (1932), and more recently Fraulein Riemerschmid of Jena University has made more detailed investigations of solar radiations in East and South

Africa (results not yet published). An American meteorologist, A. Garnett (1935), has suggested lines on which the duration and intensity of insolation could be studied in relation to the sites of settlements and agriculture.

CHAPTER V

SOIL SCIENCE

INTRODUCTION

The geological structure of the underlying rocks, together with the long-continued action of climate and of vegetation, determine the type of soil in any area. Animals, agriculture, and indeed the whole life of primitive peoples depend on this soil-vegetation unit. Therefore soil science, which is often regarded as a special branch of agriculture, is given prominence in this volume between geology and meteorology on the one hand and the biological subjects on the other.

Since agriculture began, the importance of differences of soil from place to place has been recognized, and the most primitive native agriculturalist realizes that vegetation, or the lack of it, affects soil fertility. Hence there has grown up the common practice known as shifting cultivation, which consists of allowing land to lie fallow and revert to grass, bush, or forest between short periods of cultivation.[1] This process can be envisaged as a primitive type of crop rotation in which forest is an intermediate crop. In general the members of cultivating tribes are extraordinarily good judges of land and will nearly always pick the area which has the most productive soil, but the difficulty of clearing new land and the type of timber required for domestic purposes also influences their choice. The underlying principles, according to which the type of soil controls vegetation and changes in vegetation affect soil fertility, have been studied scientifically only in recent years, and therefore soil science (or pedology, as it is now often called) is still in a state of flux compared with other more established branches of agricultural science.

[1] Shifting cultivation is considered in more detail in Chapter xiii, p. 376.

Until the war period, the geological nature of the country and the composition of underlying rocks were considered of prime importance in the formation of soils. After the war, when the work of the Russian school of pedologists became recognized in western Europe, climate was stressed as a factor of even more importance, and some authorities went so far as to claim that almost any kinds of rock, subjected to identical climate, would be reduced in time to the same type of soil. The last few years have seen a swing back from the 'dominance of climate' view, and climate is now generally ranked as a contributory factor in soil formation, together with rock structure, land morphology, vegetation and intervention by animals and man. In the tropics it is fully realized that the effect of climate on soil is much more profound than was thought twenty-five years ago. Many soil properties are now recognized as being of primary importance: among them are the varying soil texture, the distribution and nature of the humus, the constitution of the clay-substance, and the degree of acidity or alkalinity. The vertical movement of soil moisture and its seasonal fluctuation are now known to be of fundamental importance, and to depend on the interaction of numerous factors. Progress in the domain of colloid physics and chemistry has shown that the nature of the water-holding forces in the soil is more important than the total water-content. All of these factors differ not only from one soil to another but at different depths in the same soil, and are intimately bound up with its nature and suitability for different crops.

There is a prevalent idea among laymen that tropical conditions, except in desert regions of very low rainfall, imply exuberant vegetation and rich soil which lends itself admirably to agriculture by the simple process of removing the indigenous vegetation and introducing crop plants. How far this idea is from the truth is shown by the mass of intricate research which has become necessary with almost every crop. As knowledge concerning tropical soils progresses, it becomes more and more evident that to judge them from a European standpoint is entirely misleading. For instance, soils which have so high a clay content as to be totally unfit for cultivation in a temperate climate, are sometimes found to break down and become friable under tropical conditions. Against this it is

becoming evident, especially when dealing with methods of farming employed by Europeans in the tropics, that frequent manuring is necessary to maintain fertility, and often to make the soil fertile in the first place. Many native methods do succeed in maintaining a certain degree of fertility, but as population increases and commercial cultivation extends, greater demands must inevitably be made on the soil.

Soils of the arid and semi-arid parts of Africa, which make up considerably more than half the total area, contain very little humus, which is usually regarded as a main essential for the maintenance of fertility. In addition, some of the elements which are essential for all plant and animal growth, notably calcium and phosphorus, especially in the regions of high rainfall, are insufficient over wide areas.[1] In many areas tending to arid conditions there is serious trouble from 'brak' or 'alkali', usually sodium salts which are sucked up from the sub-soil under the influence of surface evaporation, and become deposited in the superficial layers, where they are often toxic to plant growth and may even form an efflorescence at the surface.

When the vegetable cover to the soil is removed, either by the plough or the native hoe in order to plant crops, or by excessive grazing of domestic animals, the great bane of agriculture in tropical and southern Africa—soil erosion—will probably begin. Even where climatic conditions or agricultural practice do not lead to erosion, suitable means for keeping the ground in production vary enormously from place to place according to the structure and composition of the local soil. Knowledge of the original soil and an appreciation of the changes involved are essential both in order to increase fertility and to prevent deleterious changes which may follow agricultural development, the burning of grassland and other human activities.

In treating African soils as a whole it is essential to make a distinction between the major geological classes. The soils of the old basement complex, derived from granites, gneisses, etc., are relatively poor, and since they spread over wide areas of the drier parts

[1] Deficiency in other minerals has been noticed in special cases, for instance the unusual case of lack of sulphur, which affects some tea soils in Nyasaland (see Chapter xii, p. 365).

of the continent, it is to them that remarks about poverty of African soils generally apply. In contrast, the soils of volcanic areas can be very rich, and so also can the alluvial soils. Conditions vary so much from place to place, however, that even these rough statements have their exceptions; for instance in Uganda some of the richest soils, especially those of Busoga, are developed from rocks of the basement complex, and many examples could be found of poor soils derived from volcanic rocks.

The *value of soil surveys* must be considered in relation to the other subjects treated in this volume. In order to obtain satisfactory results from soil surveys the field conditions of water-supply, vegetation, agricultural practice, numbers of stock, etc. must be taken into the fullest account. Vegetation may be an important indicator of soil types, and, as has been pointed out, the plants themselves and their destruction by man affect the soil very materially. For this reason many workers believe that all such surveys should be based on the soil vegetation unit, a method which is being developed particularly by Mr. C. G. T. Morison at Oxford.

A second and perhaps still more important consideration is that surveys of soil, or of soil and vegetation combined, over the vast areas of Africa must always be extremely rough, in view of the limited resources available. The question arises therefore, to what extent they can be of value in the allocation of land for different uses. In some parts of Africa surveys over a wide area would be of value to the European farmer in the choice of a farm, but in the greater part of the continent the unit farm is that of the African peasant, having an area of only a few acres, and differences in soil from one plot to the next, though often pronounced, could never be shown in the kind of survey contemplated. It would be of value only if combined with agricultural experience obtained from many small-scale experimental farms, while for opening up new areas it might be claimed that the study of vegetation, especially of plant ecology, checked by a few soil analyses, is sufficient for most purposes. Moreover, many other factors are involved in the agricultural potentialities of a territory, particularly the attitude of the native population, the cost of transport of crops and the possibilities of irrigation.

In a country without an agricultural population or developed transport, soil and ecological surveys are of great value in indicating the lines of development, as was the case in the early days of exploration in the Canadian Middle West. In most of Africa, however, there have been populations for many centuries, and long before British occupation the good soils had been discovered and developed. A soil survey made at this date can hardly be expected to do more than confirm and enlarge the knowledge already gained in other ways.

The value of soil surveys lies not in their immediate practical application, but in the data which can be obtained from them on the fundamental qualities of the soil: these data will clearly be of increasing importance as changes take place under the influence of agricultural development.

ORGANIZATION AND RESULTS

BRITISH

Before giving a sketch of the work which is progressing in each of the territories, central research institutions will be described.

The *Imperial Bureau of Soil Science* in Great Britain serves as a central organization for Empire soil science. Being associated with the Rothamsted Experimental Station under Sir John Russell, it is in the closest touch with modern research in Europe. Like the other Imperial Agricultural Bureaux (*see* Chapter XI) it does valuable work in collating literature on a world-wide basis, abstracting all important papers and bringing them to the notice of imperial and foreign workers through the medium of *Soils and Fertilizers*, a bi-monthly journal circulated to all British institutions in Africa concerned with the study of the soil. In addition, special subjects such as soil erosion, tropical crop production, and lateritic soils have been treated separately in technical communications from the bureau (Imperial Bureau of Soil Science 1930–8).

The *Rothamsted Experimental Station* at Harpenden is one of the foremost centres for soil research in the world, and also serves as a training centre. Many of the Empire soil chemists have either been trained there or have attended special courses. Empire agricultural officers meet annually at Rothamsted, on a convenient date in June,

The *Mineral Resources Department* of the *Imperial Institute* is well equipped for the chemical and mineralogical examination of soils and a large amount of work is done for the African colonies. The Institute works in close co-operation with the Imperial Bureau of Soil Science, from which soil samples from colonial sources are forwarded for examination.

The new *Soil Laboratory at Oxford* is likely to fulfil an important function as a centre for soil studies as a pure, as opposed to an applied, science.

The *Macaulay Institute* for soil research at Aberdeen has paid special attention to methods of soil survey, and is responsible for all survey work in Scotland. This institute offers facilities for the training of workers in this subject.

Conferences of soil scientists, held from time to time, serve very important functions. At the third international congress of soil science, held at Oxford in 1935, it was agreed to prepare a soil map of British Africa on the scale of 1:5,000,000, the first draft to be ready by 1940, the date of the next international congress. Mr. C. G. T. Morison agreed to act as general editor. For the foreign countries also it is hoped to publish similar maps, and M. Agafanoff (Paris) is the editor. This will make a valuable companion to the international geological map on the same scale mentioned in Chapter III, p. 71.

Among publications of a general nature the book by H. L. Shantz and C. F. Marbut (1923) on the vegetation and soils of Africa has been helpful as a basis for soil research, if only in providing something for subsequent workers to criticize. It aims at a general account of the whole continent, keeping constantly in mind the soil-vegetation unit rather than either soil or vegetation alone. P. Vageler (1933) has contributed an important book, recently translated into English, on tropical soils, partly based on work in German East Africa before the war. Another recent book of general use, though not written especially with regard to Africa, is on the biological processes in tropical soils by S. Corbet (1935). The few soil scientists at work in the continent have contributed results of value, some of which are referred to below.

In the *Union of South Africa* the Division of Chemical Services of the Department of Agriculture and Forestry at Pretoria, under

Dr. St. C. O. Sinclair, appears to be well staffed and equipped for soil investigation. In its soils section there are, besides several analytical and other assistants, twelve qualified officers, of whom eight devote their time mainly to soil survey and four to fundamental research on the structure, composition, and classification of soils. In the section of agricultural chemistry work is undertaken by some eight qualified officers and their assistants on fertilizer requirements, brak reclamations, and soil biology. The Division of Veterinary Services at the Onderstepoort Laboratory, under Dr. P. J. du Toit, studies soils in connection with mineral and other deficiencies in animal diet; and the Division of Plant Industry, under Dr. I. B. Pole Evans, undertakes soil research on pasture lands, particularly in relation to the effect of humus on fertility.

The two agricultural faculties at Stellenbosch and Pretoria and the four schools of agriculture are also studying soils, with special reference to problems of composition, alkalinity, manuring, and biology. At Pretoria University, work carried out by the agricultural department clearly indicates the great importance of the relationship between soil moisture and plant nutrients. The results already obtained throw new light on this relationship in semi-arid and irrigated soils. A committee on soil erosion, consisting of officials of various departments of state as well as representatives of farmers' and other organizations, has been in existence for several years.

A soil map of the Union, based on a survey by the division of chemistry, was published in 1929.[1] Every class of soil from gravels to heavy clays is represented in several varieties, but, in comparison with European standards, practically every soil in the Union was found to be seriously deficient in phosphorus, humus, and nitrogen. These deficiencies affect the nutritive value of the grass and so may influence the incidence of stock diseases.

Systematic classification of soils in the Union is more recent than this publication. Valuable data from portions of the summer rainfall area have, however, been collected, much of which was presented to the recent international soil congress at Oxford by C. R. van der Merwe (1935). The remaining portion of the Union

[1] The title of 'Official Soil Map' is somewhat misleading, because it was compiled not from a scientific point of view, but purely for utilitarian purposes, for farmers and others.

has been taken in hand and it is hoped to complete the preliminary survey in another five years. The following soil groups have been recognized and studied physically and chemically in some detail: 1. Laterites and lateritic red earths; 2. Yellow earths; 3. Grey ferruginous lateritic soils: (a) Brown to reddish-brown ferruginous lateritic soils; 4. Immature mountain soils; 5. Podsolic soils: (a) Prairie soils; (b) Podsolic mountain soils; 6. Subtropical semi-arid soils: (a) Reddish-brown unleached soils; (b) Black clays; 7. Desert soils: (a) Kalahari sand; (b) Kalahari sand on lime; 8. Aeolian sandy soils; 9. Solonetz soils; 10. Solonchak soils. These soil groups are climatic types, influenced, in some cases markedly, by the parent material. The decisive influence of climate on the course of weathering of rocks to soil in subtropical conditions is clearly shown in a detailed study of a few soil types in South Africa by two German scientists, Behrend and Utescher (1932).

Experiments with manures in relation to the nitrogen and carbon cycles of soils have occupied much attention in South Africa. Two recent papers are by Kamerman and Klintworth (1934) of the division of chemistry and Williams (1932) of the Cedara school of agriculture.

Soil surveys in connection with irrigation have been developed. Irrigation, especially in semi-arid regions, drastically changes the chemical constitution of the soil by removing soluble material from one region and depositing it elsewhere. Moreover, the irrigation of certain soils may result in widespread waterlogging. It is important to foresee such results, and generally the irrigation department submits proposals to the chemical division of the agricultural department, which makes a detailed survey of the area affected, especially with a view to the presence of soluble salts and the chemistry of the proposed water-supply. (Imperial Bureau of Soil Science 1930.)

In *Southern Rhodesia* there are four chemists in the department of agriculture. The geological survey has also achieved preliminary results in soil survey. Many analyses have been made, but the results are not yet published. H. B. Maufe (1915) formerly director of the geological survey, has written papers on the origin of Rhodesian soils from the underlying rocks.

In the *Anglo-Egyptian Sudan* there are five chemists, three at Khartoum and two at Gezira, who work mainly in the cotton areas and have accomplished some of the most detailed investigations yet undertaken in Africa. The whole of the southern Sudan is practically untouched from soil or other agricultural points of view, except by Mr. C. G. T. Morison (1935) who is carrying out a series of expeditions to study the soil-vegetation relationships. He hopes that his new soil department at Oxford may co-operate with the Sudan government to organize more intensive studies of the southern Sudan with a view to determining its agricultural and other potentialities. Several publications by Professor Vageler (1932–3) deal with some of the soils of the Sudan.

In the *Colonies, Protectorates and Mandates*, soil science comes under the direction of the departments of agriculture. As a rule the soil samples are collected by field agricultural officers or others interested, and are transmitted to central laboratories for study by the agricultural chemists. In *East Africa* the numbers of chemists employed in the agricultural departments are as follows: Kenya, 2; Uganda, 2; Nyasaland, 1; Tanganyika 1 (on the staff of the new Coffee Experimental Station near Moshi)[1]; Zanzibar, 1; none in Northern Rhodesia[2] or Somaliland.

The soil scientist at the East African Agricultural Research Station at Amani, Mr. G. Milne, is the one person in the African colonies whose time is given wholly to soil survey. In co-operation with the agricultural chemists in the several colonies and the assistant chemist at Amani, he is attempting a general soil survey of the East African dependencies. All data on soils collected in the several territories are sent to Amani for correlation, and soil samples from Tanganyika itself are analysed at Amani by Milne and his assistant. This work when complete, will give a good idea of the relative potentialities of land in native and settled areas, and may be expected to point the way for agricultural development. The results up to 1935 were presented at the third international

[1] Outside the Agricultural Department, Tanganyika has a keen student of soils, particularly on erosion questions, in the Pasture Research Officer of the Veterinary Department, Mr. R. R. Staples; and the Chief Engineer of the Railways, Mr. C. Gillman, has contributed notable observations on soil conditions in many parts of the territory.

[2] Mr. C. G. Trapnell, in his ecological survey of N. Rhodesia, which is referred to in more detail in Chapter vi, has already paid some attention to soils.

congress of soil scientists at Oxford, and subsequently, a provisional map on the scale of 1:2,000,000, covering Kenya, Uganda, and Tanganyika, together with a classification and description of soils, has been published (Milne 1936). Large areas of the territories are left blank, and much of the data is regarded as essentially preliminary; moreover, the author does not profess that the work in its present form can be of much value to the practical agriculturalist. Nevertheless, the publication is a most valuable summary of the present state of knowledge, and will no doubt, stimulate further work to fill the blanks.

Conferences of agricultural and soil chemists from different territories have done much to keep individual workers in touch with one another and with general advances in the science. The first for East Africa was held at Amani in 1932 and a second at Zanzibar in 1934 (Conference, East Africa, 1932 and 1935). At these the classification and nomenclature of soils, and methods of analysis were standardized. In general, East African humid soils are of types which depend for their origin on local climate rather than on the geological structure of underlying rocks, whereas dry soils fall more readily into lithological classification. The following provisional list has been adopted by all the soil chemists concerned: 1. Desert soils. 2. Saline soils. 3. Plains soils. 4. Black or grey clays. 5. Mottled clays. 6. Red earths, non-laterised. 7. Red earths, laterised. 8. Plateau soils. 9. Podsolised soils. 10. Lithological types. Details of each of these major groups are given by Milne (1936). This soil survey of East Africa has been considered in some detail because the results provide an excellent example of the type of work for which Amani exists—the correlation and enlargement of results obtained by a number of workers in the several East African colonies.

In addition to the general East African soil map, certain studies for the separate territories deserve notice. In Kenya some soil work was done by D. S. Gracie (1930) and Mr. Beckley, the present agricultural chemist, has prepared a draft soil map. For Uganda there is a draft soil map prepared by Drs. Martin and Griffith, and for Zanzibar and Pemba Islands one was prepared by Dr. L. Raymond. In Tanganyika a special study has been made of the chemistry of waters from Mount Mweru by Sturdy,

Calton, and Milne (1933). The streams, originating on volcanic rock, contain much soda in solution, and this may have serious effects on the coffee plantations on the lower slopes of the mountain.

Nyasaland and Northern Rhodesia are not included in the East African map. For the former A. J. W. Hornby (1935) has published a detailed soil map of the territory at the south end of Lake Nyasa, in connection with the agricultural survey, and he has prepared a draft map of the whole country. For Northern Rhodesia, C. G. Trapnell and J. N. Clothier (1937) have published soil-vegetation maps for the north-western area as a result of the ecological survey.

In the *West African Colonies* there are three agricultural chemists in Nigeria, one in the Gold Coast, none in Sierra Leone or the Gambia, but the Director of Agriculture in Sierra Leone, Dr. F. J. Martin, was formerly chemist in the department, and is one of the pioneers of African soil science. Periodic interterritorial conferences have not yet become established recurrent events as they have in East Africa; the last held was the second conference of West African agricultural officers, in the Gold Coast in 1930 (Conference, West Africa, 1930), which included a section devoted to soil science.

Nigeria is a difficult country to cover by soil survey on account of the extreme diversity of conditions, but for this very reason—the large variation in climate and geology over what in Africa is a small area—work there might achieve results of fundamental importance comparatively quickly. The three agricultural chemists have already done much.

In the Northern Provinces a chemical laboratory is maintained at Samaru where the work deals mainly with animal nutrition and soil analysis of a specialized nature, mostly concerning local manurial trials and pot experiments with farmyard and artificial manures. The Moor Plantation Laboratory at Ibadan, where Mr. Doyne is the chief chemist, is carrying out a soil survey of Nigeria, in addition to soil investigations directly connected with the work of the agricultural department. Some thousands of soil samples have been collected, many being profiles taken several feet in depth, and most of these have been analysed. The variation

of soils in Nigeria is enormous, as would be expected in a country ranging in altitude from sea-level to over 13,000 feet, and in rainfall from over 300 inches annually in the Cameroons to under 25 inches in the north. The pH, for instance, was found to range from 9 (very alkaline) in the limestone region near Lake Chad to under 4 (very acid) in the pleistocene area in the south of Benin Province. The practical results which can be expected from an understanding of soils are shown by the fact that, in certain very acid soils with a pH of 4·0–4·3, a small dressing of lime (sufficient to raise the pH to 4·8 or 5·0) increased the yield of maize appreciably, but heavier dressings had a definitely depressing effect on the green manure crops. As another example, which is a most significant discovery, it has been established on the experimental stations of the agricultural department at Zaria and Kano that small applications of farmyard manure—one to two tons per acre compared with the usual ten tons per acre in England—produce astonishing responses in increased yields of guinea corn and cotton. Hartley and Greenwood (1933) have done important work on this.

The trend of recent work in Nigeria is to indicate that, both in the humid and semi-arid regions, the lack of mineral plant food, particularly phosphorus, is a more important factor than the lack of nitrogen; but nitrogen and humus appear to become more important again in the very dry areas. The mere fact that in the humid tropics good crops are obtained immediately after clearing old bush may be largely due to an accumulation of mineral matter which is set free by the rapid oxidation of the humus rather than to nitrogen derived from the humus. For in Nigeria it is found that, in soils under high bush or forest, the base status and pH are high at the surface, but diminish rapidly with depth; whereas on a soil which has long been under continuous cultivation this is not the case.

In the *Gold Coast* the agricultural chemist has, since 1931, been able to devote most of his time to work on the soils. Attention is being given mainly to cultivated lands, but work is resulting in a general classification. Already several hundred samples have been examined, and the work aims at a soil survey of all cultivated lands, which should be ready soon. A map showing the results

would certainly be a valuable addition to the published Atlas of the Gold Coast.

Sierra Leone was the first British colony to have a soil survey completed in outline; it was done by Martin and Doyne (1932) and was based on the analysis of 1,500 samples, each taken to a depth of four feet. Problems here are relatively simple since conditions are similar over most of the territory. Laterite or lateritic soils[1] predominate, with a resultant lack of lime and preponderance of acidity; phosphorus and potassium contents are low, and humus is high before cultivation, but very low afterwards. Surveys such as this provide a useful basis for further study, but the authors would be the first to point out that additional information is necessary in order to determine the areas suitable for different crops. Studies of the relation between the vegetation distribution and soil types are required and then the agricultural significance of soil type and soil change should be worked out, but the agricultural department no longer includes a chemist who could undertake such work.

FRENCH

In French territory studies of this and of other subjects have been carried further in Indo-China and Madagascar than in Africa. The laboratory of agricultural chemistry at Tananarive in Madagascar for example, has published during the past few years numerous soil studies, some of which are important in relation to work on the African continent. In *French West Africa* there are now agricultural chemists at the chemical laboratory of the Office du Niger at Segou in the Sudan, at the experimental station for groundnuts at M'Bambey in Senegal and in the Ivory Coast. Wide-scale soil survey has not been attempted, but important researches have been carried out, in connection with the cultivation of the banana in French Guinea, and of the oil palm in the Ivory Coast, and others in the Sudan in connection with the Niger irrigation works. The laboratory attached to the botanic

[1] The terms laterite and lateritic have been used somewhat loosely by some authors. Martin and Doyne (1932) laid down precise definitions based on the silica-alumina ratios: soils with a ratio less than 1·33 are laterite, from 1·33–2·0 lateritic, and above 2·0 non-lateritic. That definition has been used in their soil survey of Sierra Leone, but most workers now incline to the view that though the ratios may be used to define the *terms*, they have little relation to any soil property.

gardens at Hann near Dakar has devoted some attention to the local soils.

In *French Equatorial Africa* little research work has been done in agricultural subjects, but the active geological survey may be expected to produce valuable results on soils. *French Somaliland* is too small to warrant a special agricultural service or chemical work, but various geological expeditions there have made some observations on the soils. Results of these studies have not appeared in any form available to the public.

BELGIAN

In the Belgian Congo the importance of this subject is realized, and the *Institut National d'Agronomie Coloniale* is proposing to start a reconnaissance soil survey. Professor L. Baeyens, head of the Pedological Institute of Louvain University, spent some months in 1934–5 in the Congo for this purpose, and visited the soil chemists at Amani, Nairobi and Kampala. For the *Katanga* region an essential part of the scientific programme of the Comité Spécial is the production of maps of topography, geology, soils, vegetation, etc. (as mentioned in previous chapters). The soil maps already published in the *Atlas du Katanga* (1931) are probably as complete as those for any other part of Africa. It appears that the maps have been prepared largely from the superficial appearance of the soils, but work on analyses is progressing, and the details will be filled in later.

DETERIORATION AND EROSION OF SOILS

In the development of virgin country the problem of soil deterioration is reflected in every activity connected with agriculture; it is therefore, one of the main themes running through this volume. Nearly every science has some bearing on the subject. It has been pointed out that in many parts of Africa knowledge of the soil itself is still deficient. Then the effects of climate, of water-supplies, of plants and animals, and above all, of human activities must be considered. In southern Africa, as a whole, the stock-bearing capacity of the land has been progressively reduced over a long period of years, and many native reserves have been devas-

tated by soil erosion. In eastern Africa overstocking and destructive methods of cultivation are steadily reducing the productivity of land which is required for an increasing native population. In western Africa the destruction of forest has also played its part, and in some areas the pressure of population on land of which the fertility has been reduced to a dangerously low level provides an administrative problem of some urgency.

Nearly every report from Africa on agriculture, animal husbandry, forestry or geology, refers to the serious nature of the erosion problem, and most of the special enquiries bearing on agriculture have attempted to analyse the position and to suggest measures for its amelioration. Among them may be mentioned the report of the South African Drought Commission (1923), the report of the Agricultural Commission in Kenya (1929), the report of the Kenya Land Commission (1934), and the enquiry in Southern Rhodesia into the economic position of the agricultural industry (1934). These and other enquiries have borne fruit by making the urgency of the problem widely known, but they have been limited to certain aspects only, with the exception of the South African Drought Commission, of which the report deals only with a small part of the continent and will soon be out of date.

The Imperial Bureau of Soil Science produced a short report on soil erosion in 1933, and a fully documented report (1938) describing the causes of erosion and the measures taken to control it in every affected country in the world.

Soil erosion is usually divided into sheet erosion and gully (donga) erosion according as the surface soil is removed bodily from wide areas of country, or ever-deepening water channels are cut through the soil and underlying deposits. This distinction is drawn for example, by Champion (1933) and Hobley (1933) with reference to Kenya. It is perhaps more exact to divide the damaging effects of soil erosion by water into four categories, which rougly represent the stages of damage as erosion proceeds. These are: 1. Soil is washed from the surface of sloping land; 2. This soil is deposited on flat land at the foot of the slopes, but in the condition of infertile débris, because the original mixed ingredients are sorted by water action, the coarse sands being deposited on the

upper parts and the heavy muds on the lower. The effect of this deposition is often to bury fertile soils on the flat land with infertile débris; 3. The increased run-off which follows these processes causes serious torrents which cut gullies or dongas deep into the subsoil. At the same time flooding may lead to destruction in lower parts of the drainage systems; 4. These three processes tend to lower the ground-water table in every part of the country. In addition to the effects of water, erosion by wind is often serious, for in areas where high winds are coincident with the dry season, as in the rift valleys of eastern Africa, pulverized soil is often carried away in the form of dust storms.

The factors leading to soil erosion can be divided into the natural agencies, which result in the first place in the breaking down of rocks to form soil, and later under special conditions, in a loss of soil quantity and quality; and into human activities, agricultural and other.

In discussing natural agencies in soil erosion, authorities, especially in South Africa, have emphasized the alleged progressive desiccation of Africa which is supposed to have led, not only to the conversion of wide tracts of fertile country into desert, but also to the deposition of alkali or brak[1] over wide areas. This progressive desiccation has been discussed in Chapter IV, where it was pointed out that there has certainly been a great change since the pluvial periods, some 10,000 or 15,000 years ago, and that this change may still be continuing to-day. Most authorities are now agreed, however, that although reduction in rainfall may have had a slight effect in localized areas, the recent spread of desert conditions which has undoubtedly affected wide areas, especially in South Africa, is due principally to human agencies.

The effect of human activities depends on the basic principle that when the natural cover of vegetation over the earth is removed and the elements are allowed free play, the soil is seriously affected or even washed away bodily. Increases in human and cattle population since the arrival of the white man are held to be largely responsible for the erosion of the African soil. There are, however, areas where the population has remained at a steady

[1] Under arid conditions the subsoil waters are raised near to the surface, and on evaporation deposit their dissolved salts as brak in a form which is often toxic to plant life. When storm rains come they wash away not only the brak but the soil itself.

low level for the last forty-five years, and yet the productive capacity of the land has been systematically destroyed. The western section of the Kamba tribe in Kenya is a case in point, and their outlook to-day is very serious: their country has been well-nigh ruined, they can no longer migrate elsewhere and famines are frequent. The country occupied by the Sukuma south of Mwanza in Tanganyika is also in a bad condition owing to overstocking, although the population has probably not increased much since European occupation. As a third example the great migration of the Jaluo (Nilotic Kavirondo) southward from the hills east of Gondokoro to their present situation on the Kavirondo Gulf of Lake Victoria, is held by some to have been caused by decreasing fertility of the land they left. Whether or not soil erosion was common before the European occupation of Africa, the coming of the white man has probably given it a stimulus by causing increase of population and at the same time encouraging the extension of cultivation.

The human activities which produce erosion are shifting cultivation combined with land hunger and overgrazing, each of which is considered fully in Chapters XIII and XIV. Some authorities would make a third category, namely fire, but burning of forest or grassland is usually a feature of the native agricultural systems, though it is also carried out in some areas to facilitate movements of man for the purpose of collecting wild products such as honey and gum. It is alleged that pastoral tribes associate the dry grass with tick-borne disease such as east coast fever, and the burning does in fact destroy the ticks. In some parts annual burning appears to be a traditional practice for which no economic reason is given. Undoubtedly the burning of vast areas of grassland and savannah forest is a more potent factor in destroying vegetation in some districts than is either grazing or cultivation, and it lets in the desert on an extensive scale in arid regions.

It is only during the last fifteen years or so that attention has been focused on the dangers of soil deterioration, but it is important to realize that the European influences to which soil erosion is partly ascribed have been at work in parts of the continent for some centuries. T. D. Hall (1934) for example, in summarizing the historical evidence for South Africa, points out that changes in

the character of natural vegetation were noticeable as early as 1751, within one hundred years of the first settlements, and that these changes can only be attributed to the effects of overgrazing. Indeed there are many examples of erosion in southern and eastern Africa which have resulted from European methods of farming.

Once the causes are recognized and the best ways of preventing erosion are discovered, it is comparatively easy to arrest the trouble on land under management by white peoples. A much greater problem is to be faced in the vast areas farmed by Africans, whose methods can be controlled only with extreme difficulty by European administrative officers and agriculturalists.

The collection of data in the field, showing the severity and extent of damage to the soil in each territory, is urgently needed. Such surveys of soil erosion are being made in parts of Africa, and the subject was discussed at the second conference of East African soil chemists in 1934 (East Africa, Conference, 1935), when a paper by Mr. Gethin Jones outlined the results of a reconnaissance survey of the extent of soil erosion in Kenya. In Uganda also, a special survey has been made for the Teso district and a wider survey of the protectorate is also being conducted. It is to be hoped that further studies of this type will be organized.

The question of soil erosion is closely allied to that of the regulation of water-supplies. It is generally admitted that the destruction of natural vegetation, forest or otherwise, adversely affects the water-supply, causing floods in times of heavy rain and the disappearance of springs and streams in the dry season, while the maintenance of the natural vegetation prevents run-off and causes rain water to percolate into the soil and issue subsequently in the form of springs. One of the most complete investigations into this question has been carried out in the northern part of Tanganyika by Teale and Gillman (1935), as mentioned in Chapter III. The conserving power of forest reserves in suitably chosen areas is now widely recognized, and action is being taken with regard to their creation or enlargement in many parts of the continent; these questions are discussed in Chapter VII. Agricultural methods of soil conservation are considered in Chapters XIII and XIV where the subjects of cultivation and animal husbandry are discussed in some detail in relation to soil deterioration and erosion.

Among recent publications on remedial measures are articles by the agricultural engineer in the Rhodesia Agricultural Journal, by Ducker in the Empire Cotton Growing Corporation's Journal, and by Harrison in the East African Agricultural Journal. Beckley (1935), the senior agricultural chemist in Kenya, has also produced a valuable bulletin with many practical details of anti-erosion methods which are applicable in that country.

SOIL BIOLOGY

The study of the flora and fauna of different soils and their effects on fertility has not been highly developed, even in Europe. In Africa it has scarcely been touched, though recently the division of chemical services in the Union has established a small soil biological section which is now studying questions relating to the nitrogen cycle and humus supply in pastures and citrus orchards. The study of bacteria will probably be the most fruitful on account of their role in the food-cycle from soil to green plant to animal, particularly in connection with the fixing of atmospheric nitrogen by the roots of leguminous plants. As has been mentioned, recent work, especially in Nigeria, suggests that on the whole the presence of mineral salts has more influence than that of nitrogen on fertility, but at the same time it is a general experience in Nigeria and elsewhere that an intermediate crop of leguminous plants increases fertility very considerably.

Other organisms also offer wide fields for study, and may well prove to be of great economic importance. The role of moulds and other fungi in soil economy may rival even that of bacteria. In particular, the association between fungus and plant root known as *Mycorrhiza* is essential for the germination and growth of many plants. The importance of mycorrhiza in orchids and heaths is widely recognized, but it is not so widely known that many kinds of forest trees must have the correct specific fungus in the soil in order to flourish. This subject has scarcely been touched in Africa, though a fair amount of work has been done on mycorrhiza in other parts of the tropics, notably by Dutch workers in the East. It has been estimated that some 70 per cent. of failures to re-establish plantations of local forest trees are due to lack of the right mycorrhizal fungus in the soil. Again, the importance of

protozoa in the soil has been stressed by workers in England, but the group has not been studied in tropical conditions.

One way in which such biological studies may give fruitful results is in relation to the use of mulches and manures. In Uganda for example, marked success has been achieved by using cut grass as a mulch for coffee. This effectively prevents erosion and soil deterioration, but the reason is not known. A comparative study of the biological and chemical changes occurring when the mulch is, and is not used, would be of value, and might be undertaken at Amani in collaboration with the technical staff of the territories interested.

One particular group of animals, the termites or white ants, of which many species are abundant in Africa, deserve special attention. The ground forms are certainly agents in soil evolution since they are continually occupied in bringing to the surface quantities of subsoil, or partly weathered rock, in order to build their termitaria, but the effect on fertility is not yet known. Vageler (1933) states that in tropical Africa termitaria directly enrich the soil, and experience in Nyasaland at the Zomba Experimental Station also seems to indicate that their effects are beneficial; but Dr. A. L. du Toit (1934) writing on South Africa, suggests that termites do immense harm by cutting up, consuming, or storing grasses and other growth, and thereby prevent the formation of humus. Dr. T. J. Naudé (1934), in one of the few studies so far published on termites in relation to agriculture, also stresses the effect of these insects in pastoral areas in South Africa. He considers that drought conditions favour termites, and that, in the recent succession of dry years which South Africa has suffered, the denudation occasioned by termites has had a considerable bearing on soil erosion and the loss of storm water by increasing the run-off.

In arid regions, where wood and green vegetation are scanty or lacking, termites are still numerous and must have food. The habit which many species have, of cultivating fungi in their nests, may provide this to some extent, but it has been suggested also that they can feed directly on humus, and thus may be in part responsible for the poverty of so many soils. In many parts of Africa there are huge extinct termitaria, which are used by natives for cultivation. These insects are considered more fully in Chapter X.

CHAPTER VI

BOTANY

INTRODUCTION

PLANTS depend directly on the physical and chemical conditions of their environment, which are included in the sciences considered in the last four chapters. The study of botany is also intimately related to the applied sciences of forestry and agriculture. Furthermore, the fact that all animals depend upon a food-chain which contains plant products as its fundamental link renders the study of vegetation a basic necessity in relation to all questions affecting animal nutrition.

No distinction between pure and applied science can be drawn in the case of biological studies, since a sound knowledge of taxonomy, morphology, histology, physiology, ecology, genetics, and kindred subjects is directly relevant to all practical questions. For example, in studies of the pasture-lands which cover so large a part of Africa, the identification of species and varieties of grasses legumes and other fodder plants cannot be sharply divided from the discrimination of those of value for stock, and the study of conditions under which they increase. Again, in order to understand the economic potentialities of rain-forests, studies on the classification of trees, the histology of wood, physiology and forest ecology are indispensable. In this chapter an attempt is made to state the present position in Africa of botanical studies as a basis for economic applications in forestry and agriculture.

It is convenient, though somewhat arbitrary, to divide the results of botanical researches under four headings: (1) Taxonomy, including the identification and classification of plants; (2) Ecology, or the study of plants in relation to their environment, plant associations, changes in the type of vegetation as a result of activity,

human or animal, etc.; (3) Selective breeding for economic purposes; (4) Plant pathology, which again is concerned mainly with crops. Plant breeding and pathology are discussed in relation to other studies of each kind of crop in Chapter XII so the present chapter is devoted mainly to taxonomy and ecology. Special sections are devoted to the improvement of pasture-lands, to which ecology is closely relevant, and to the conservation of the unique flora of the continent. Several of these subjects are dealt with in later chapters, notably Chapters VII, IX, and X.

The question arises here, as in other subjects, of the value of the survey method in estimating the potentialities of land. It is certain that the study of ecology, and particularly that branch of the subject which deals with the changes in vegetation produced by human intervention, is of extreme importance, and for this reason considerable space is devoted to it below. Though the addition of plant ecologists to the several agricultural departments would be highly desirable, it must be admitted that any large ecological surveys are probably not justified at the present stage of development.

Stress must be laid again on the soil-vegetation unit, since the use of this as a basis of research is one of the principles which distinguish the ecological from the purely botanical survey. It is not intended, however, to minimize the importance of the relation between plants and climate, physiography and animals, all of which must be included in any ecological study. As the science advances it becomes increasingly evident that one man cannot deal with all aspects, and recourse must be had more and more to team work.

Studies on ecology and most researches devoted to breeding and pathology can only be carried out in Africa itself. As regards taxonomy, the position is somewhat different because the flora of Africa is so diverse that one expert can, as a rule, only deal effectively with a comparatively small group. Moreover, owing to the fact that most of the African flora has been described by botanists working in European herbaria, the 'type' or authentic specimens of the species described are preserved in British or Continental institutions. Therefore, however carefully field studies are now carried out in Africa, the taxonomist must still largely rely on

Europe, since it is often necessary to compare his plants with authentic specimens. For these reasons it is impossible for any single territory, with the exception, perhaps, of the Union of South Africa, to become self-supporting in regard to taxonomy. The growth of headquarters of research like that at Amani, serving a group of territories, will in part make good this latter deficiency. The present method, whereby systematic work is undertaken at central institutions in Europe, is both necessary for the reasons mentioned, and obviously efficient, provided there are members of staff at these institutions ready to devote a large part of their time to routine identifications. Amongst the most important of these institutions are the Royal Botanic Gardens at Kew, the British Museum (Natural History), the Botanic Gardens at Brussels, Stockholm, and Berlin, the Natural History Museum in Paris, and Coimbra University in Portugal.

ORGANIZATION

BRITISH

In Great Britain the *Royal Botanic Gardens at Kew* serve as the headquarters for Empire botanical investigation, and do important advisory and other work besides systematic botany. Activities in the herbarium, which is the largest and most representative in existence, are of necessity directed to the systematic side. Studies of native crop plants are undertaken by the Economic Botanist, who has recently written a most valuable book on crop plants of the British Empire (Sampson 1936). Studies at Kew involve not only the designation and description of the different plants, but include suggestions for trials under diverse conditions. Seeds sent from Africa to Kew are distributed for trial to the agricultural research stations at Amani, Trinidad, and in India.

Until the dissolution of the Empire Marketing Board several members of the Kew staff, in particular Sir Arthur Hill, Director, Mr. H. C. Sampson, Economic Botanist, Mr. A. D. Cotton, and Dr. J. Hutchinson, were given grants for visits to Africa to consult with local experts and investigate special subjects, but the continuation of this practice now depends on invitations from the individual governments. The great Floras entitled *Flora Capensis*,

in seven volumes, *Flora of Tropical Africa*, in eight volumes, and *Flora of West Tropical Africa*, in three volumes, are amongst the important works on the systematic botany of Africa which have been published at Kew.

The *Bulletin of Miscellaneous Information* and other reference works mentioned in the bibliography are also published from the Gardens. Sir Arthur Hill in an article in *Nature* (1937) has described the relation of the work at Kew to that in the Dominions and Colonies.

The Botany Department of the British Museum (*Natural History*), under Mr. J. Ramsbottom, who visited South Africa, Rhodesia, and Kenya in 1929, has an herbarium which is second only to Kew among herbaria in the British Empire. It possesses important collections from many parts of Africa, including early historic collections from South Africa. The Museum has published several important works on African plants, notably Welwitsch's African plants and Talbot's Nigerian plants (British Museum 1896–1901 and 1913), and is at present collaborating with the authorities at Coimbra University in Portugal in publishing a flora of Angola, (Carrisso 1937 onwards). Studies on systematic botany relating to Africa by members of the department are numerous, and collecting expeditions to the Gulf of Guinea by A. W. Exell, the Sudan by J. E. Dandy, Mount Ruwenzori and other mountains by E. Taylor, and Angola by A. W. Exell, have recently been undertaken by members of the present scientific staff.

Valuable monographic works have been published by specialists at the Museum. Of these, E. G. Baker's volume on the *Leguminosae* of Africa, J. E. Dandy's work on *Potamogeton*, and A. W. Exell's work on the *Combretaceae* may be mentioned. Further treatises are in hand by G. Taylor (*Podostemaceae*) and A. G. H. Alston (*Selaginella*).

The *Imperial Forestry Institute, Oxford*, which has a forest botany section including a forestry herbarium, under Dr. J. Burtt Davy, serves as a headquarters in England for that subject. Its work is described in Chapter VII.

The *Imperial Mycological Institute*, under Mr. S. F. Ashby, is the central headquarters for the study of all fungi of economic importance. It has recently come under the control of the Executive

Council of the Imperial Agricultural Bureaux (see Chapter XI).

In the *Union of South Africa* the Division of Plant Industry of the Department of Agriculture and Forestry under Dr. I. B. Pole Evans has instituted a botanical survey. The total staff numbers one hundred and nine, and includes nine systematic botanists. In addition to these permanent officers of the government, the botanical survey has the co-operation of certain university botanists, notably Professor R. S. Adamson of Capetown, Professor J. W. Bews of Natal, Professor W. J. Lutjeharms of Bloemfontein, and Professor J. Phillips of the Witwatersrand University, each of whom undertakes the investigation of systematic botany and ecology in a defined region.

South Africa is well equipped with reference collections of plants, as shown by the following list of herbaria: At Capetown—the Bolus Herbarium at present attached to the National Botanic Gardens at Kirstenbosch and shortly to be removed to the University of Capetown, the South African Museum Herbarium, and the Herbarium of the University of Capetown; at Stellenbosch—the Herbarium of the University; at Grahamstown—the Albany Museum Herbarium; at Durban—the Natal Government Herbarium; at Kimberley—the McGregor Museum Herbarium; at Pretoria—the National Herbarium and the Transvaal Museum Herbarium; at Johannesburg—the Herbarium of the Witwatersrand University. There is one large botanical garden in South Africa, at Kirstenbosch near Capetown, the director of which, Professor R. H. Compton, is also a Professor at Capetown University; an interesting garden is attached to the Stellenbosch University and another is at Matgesfontein on the Karroo. There were formerly five other botanical gardens, but all of these have now been replaced as centres of botanical science by the new agricultural experimental stations and forestry arboreta.

Southern Rhodesia has a Department of Agriculture to which two plant pathologists are attached. The post of systematic botanist was suppressed during the financial depression. There is also a Department of Forestry which has carried out extensive work and which maintains a considerable herbarium. A large general herbarium of Rhodesian plants is also to be found in the Queen Victoria Memorial Museum, Salisbury.

In the *Sudan* two economic botanists are included in the staff of the Gezira agricultural research service, and the director of agricultural research formerly on the botanical staff, still supervises the plant-breeding work, which is concerned mainly with cotton.

In the various *Colonies, Protectorates, and Mandated Territories* it is difficult to assess the number of workers engaged on botanical subjects, because the title of 'botanist' is not always used in the same sense in the different territories. However, the following officers belonging to agricultural and veterinary departments are, according to recent departmental reports, engaged for at least part of their time on research: Northern Rhodesia—an ecologist and an agricultural officer in charge of ecological survey; Nyasaland—none; Tanganyika—one plant pathologist in the Agricultural Department, one botanist in the Veterinary Department on pasture research, and one in the Tsetse Department on botanical survey; Kenya—two plant breeders, two plant pathologists, and one agricultural officer investigating grasses[1]; Uganda—three botanists and one mycologist; Nigeria—six botanists; Gold Coast—one botanist; Sierra Leone—one plant pathologist. In addition to these the East African Agricultural Research Station at Amani has a systematic botanist, a plant breeder, a plant physiologist, and a pathologist, and the Empire Cotton Growing Association maintains a research staff distributed in Nyasaland, Northern Rhodesia, Southern Rhodesia, the Sudan, and the Union of South Africa, some members of which are occupied in plant-breeding work. The Departments of Forestry in each of the territories include officers who spend much of their time on botanical work, some of which is mentioned in this chapter. The majority of the botanical staff mentioned above is of necessity occupied with the investigations of immediate economic problems, such as the production of improved strains of crop plants, the control of fungoid diseases or improvement of pastures. Amongst botanists permanently engaged in long-term research in tropical Africa are the ecologist in Northern Rhodesia, the botanical survey officer of the Tanganyika Tsetse Department and the systematic botanist, physiologist, and pathologist at Amani. Botanical study in Africa has benefited much from

[1] There is also a botanist at the Coryndon Memorial Museum at Nairobi, a government-aided institution.

a number of scientific and other officers in the colonies who have taken up the study of the flora as a hobby, and co-operate with institutions in England. A part of the botanical work in Africa has resulted also from scientific enterprise carried out under the auspices of universities in Europe and South Africa. This field for the activities of British scientists seems to be capable of expansion, particularly in West Africa, which has not attracted the scientist nearly so much as the east.

Most of the agricultural and forestry departments are collecting herbaria of the native flora which serve as important reference collections. There are also a few botanical gardens, on which, however, expenditure has recently been much reduced. Ideally, a botanic garden should be staffed to build up an herbarium and to meet the local needs of systematic botany and perhaps also plant ecology, and should maintain close co-operation with agricultural experimental stations. The educative value of botanic gardens is one of their great assets, and for this reason it might be undesirable to develop them before centres of higher education are definitely fixed. Establishments like Makerere in Uganda, Achimota in the Gold Coast and Yaba in Nigeria, will eventually require botanic gardens near at hand, as they grow to the status of universities.

The more important centres of botanical research already in existence are as follows: in *East Africa* the research institute at Amani, of which Mr. A. H. Glend Hill is director, was originally established by the German administration, and now has a large-scale acclimatization station together with departments for physiology, genetics, biochemistry, and plant pathology. There is also a large herbarium in charge of Mr. P. J. Greenway from which information is constantly supplied for purposes of agriculture, forestry, animal husbandry, toxicology, and medicine. Tanganyika also has a herbarium at Shinyanga, for collections made by members of the tsetse research department. In Uganda there is a botanic garden at Entebbe, which serves a useful purpose as a place where plants of potential value, from either the economic or decorative aspect, can be grown under observation, and distributed, but this last function is now largely met by a private nursery established near Nairobi. A well-stocked herbarium is attached to the agricultural department at Kampala, and the forest department

at Entebbe also has a representative collection of woody plants. In Kenya there is an excellent arboretum at Nairobi under the conservator of forests and the grounds around the Scott Laboratories are used as an acclimatization station. There is also a herbarium attached to the agricultural department, and a good herbarium at the Coryndon Memorial Museum in Nairobi. In Nyasaland the agricultural station at Zomba is used as an acclimatization station and the forest department has its own arboretum.

In West Africa, *Nigeria* has the Moor Plantations, the headquarters of the agricultural department, which are used for acclimatization purposes as well as for agriculture. Several of the other agricultural stations have developed from botanical gardens which were originally in the charge of gardeners sent out from Kew, and some are still used for the acclimatization of plants. There is, in the Cameroons, the Victoria Botanic Garden established under the German administration. This was far the finest garden in West Africa, but much of it has now been abandoned, and for the remainder the upkeep has been reduced to a bare maintenance level. There is a herbarium at Victoria, and another, which is of larger size and better kept up, has been established by the forest department at Ibadan. In the *Gold Coast* the Aburi Garden, where many of the technical officers of the agricultural department have their headquarters, was established about 1890, and is used for acclimatization purposes and for horticulture. An herbarium of forest plants is maintained at Kumasi, and a larger herbarium, containing over 10,000 named sheets, has been built up at the biological laboratories of Achimota College. In *Sierra Leone* the headquarters of the agricultural department is at Njala, where there is an acclimatization station and an herbarium.

With regard to the future of botanical research in British territories, it is clear in the first place that the breeding of crop plants and the study of pathological problems will always be required. Concerning natural vegetation, it can be claimed that, though far from being perfectly known, most of the common plants excepting the lower orders such as fungi and mosses, are now sufficiently listed and described to provide a working basis for other subjects. Accordingly studies in plant physiology and ecology are becoming really profitable. Ecological studies, to be comprehensive and use-

ful, must include the effects of cultivation and animal husbandry, which are among the most important factors in Africa. Their study in relation to the native flora will provide a valuable connecting link between botany and agriculture. The Imperial Botanical Conference in 1924 set up the British Empire Vegetation Committee to further the study of ecology, and the book edited by Tansley and Chipp (1926) on the aims and methods in the study of vegetation, published by the committee and circulated widely in the Empire, has stimulated interest in the subject, and has been of great value to local workers. The British Ecological Society, founded in 1913, publishes the *Journal of Ecology*, many contributions to which are mentioned in the bibliography.

The development of ecological survey work would have important practical results through the light thrown on the effects of agricultural developments, afforestation and deforestation, erosion, etc. The ecological survey of Northern Rhodesia, carried out by one botanist and one agricultural officer, has already shown important results in a few years. From time to time suggestions have been put forward for the inauguration of wide-scale ecological surveys by co-operation between adjacent territories. For instance, J. F. V. Phillips (1931a) outlined an ambitious scheme for South, Central, and East Africa. The organization of work on a large scale at present would be premature, for the methods of ecological survey to produce the most useful results have yet to be worked out for African conditions. The ecological survey of Northern Rhodesia and that started by the department of tsetse research in Tanganyika provide admirable bases for future development.

FRENCH

The headquarters of systematic botany in France are at the *Musée National d'Histoire Naturelle* in Paris, under Professor Humbert. He and members of his staff have travelled and collected widely in Africa and Madagascar. His colleague, Dr. A. Chevalier, Director of the section devoted to *Agronomie Tropicale* and *Productions Coloniales d'Origine Végétale*, is in the closest touch with the problems of the African colonies, and has published very extensive material dealing with them.

In French Africa there are practically no botanists except plant

was carried out by H. Bolus, Schönland, Marloth, and Medley Wood. The work published under the direction of Dr. I. B. Pole Evans from the Division of Plant Industry at Pretoria is very extensive, some of the most important contributions being those of E. P. Phillips, I. C. Verdoorn, R. A. Dyer, and H. G. W. J. Schweickerdt. In addition to these government workers, much investigation has been carried out by other Transvaal botanists, specially by C. E. Moss and Mrs. Moss (University of Witwatersrand), Miss A. A. Obermeyer and C. E. B. Bremekamp, whose paper on the origin of the flora of the Kalahari is of particular note. Systematic research in the Cape Province is centred at the Bolus Herbarium, whence many important papers have been published, notably by Mrs. L. Bolus (present Curator) and N. S. Pillans. Valuable work has also been carried out at the Stellenbosch University, especially by P. A. van der Bijl and Miss A. V. Duthie. From the University of Capetown R. S. Adamson has published important treatises (*see under* Ecology) and Mrs. Levyns several important systematic papers, including a useful handbook on the Flora of the Cape Peninsula (1929b). The publication of a new Flora of the Cape Peninsula has been commenced under the general direction of Professor R. H. Compton. For Natal and Zululand J. S. Henkel has published a book on woody plants (1934), and for the whole of the Transvaal Dr. Burtt Davy (of the Imperial Forestry Institute) is preparing a Flora embracing the flowering plants and ferns, of which two parts (1926 and 1932) have been published. Numerous other works of high value on plant systematics have resulted from the Botanical Survey of the Union of South Africa. Poisonous plants have been dealt with by E. P. Phillips (1926) and later by Watt and Breyer-Brandwijk in their important volume entitled *The Medicinal and Poisonous Plants of South Africa* (1932). In the field of biochemical and physiological research, Dr. Marguerite Henrici has made valuable contributions on various problems connected with the study of South African grasses and other pasture plants. Further details need not be given here, since Dr. E. P. Phillips (1930) has provided an historical sketch of the whole development of botanical science in South Africa.

Southern Tropics

For the south tropical region the catalogue of Welwitsch's African plants, prepared by the British Museum Department of Botany (1896–1901), is a monumental work; it is published in five parts running to 1,350 pages and is based on the finest collection of plants ever made in tropical Africa. Another work on this region is the enumeration of John Gossweiler's Angolan plants, published continuously since 1926 as a supplement to the Journal of Botany, and already running to about 450 pages (Exell, Good and others 1926 onwards). A critical revision of all the Angola material from the great herbaria is being prepared by members of the staff of the Department of Botany in collaboration with Mendonça to be published in a work entitled *Conspectus Florae Angolensis.* The first volume of this, by L. G. Exell and Mendonça, which covered the families from Ranunculaceae to Malvaceae, appeared in 1937. Many other studies on the Angolan flora have been published in Portugal, mainly from Coimbra University.

The Rhodesias are not well equipped with systematic reference works, but the list of Southern Rhodesian plants by F. Eyles (1916), though now out of date, has proved valuable. Two Swedish expeditions have contributed to our knowledge of the Rhodesias. The first, under Graf von Rosen (1911–12), visited Northern Rhodesia, and the second and smaller expedition of 1930, led by Th. Fries, explored the Inyanga Highlands of Southern Rhodesia. The botanical results of von Rosen's expedition have been published by R. E. Fries, and those of the second expedition are being dealt with in a series of monographic studies by various Swedish botanists. E. Milne-Redhead has made two extensive tours in Northern Rhodesia, the first in connection with the aerial survey of that territory. His collection has been named and the MS. list is available for consultation. For Nyasaland Burtt Davy and Hoyle (1937) have compiled a check-list of all the forest trees and shrubs.[1]

Central Tropics

For the central tropical region, Professor Engler and the staff of the Botanical Museum at Berlin have published much material on East Africa, Dr. Engler's own work (1891 and 1895) being especi-

[1] See Chapter vii, p. 198.

ally valuable. Dr. Burtt Davy is preparing check-lists of the forest flora,[1] in collaboration with officers of the forestry departments. E. Battiscombe's useful book on the common trees and woody plants of Kenya has been revised (1936).[2] Our knowledge of the high mountain flora of Africa was summarized by Engler in his *Hochgebirgsflora des tropischen Afrika* (1892), and numerous works of a general nature published since then have added considerably to it. Humbert and Mildbraed are prominently connected with the subject, and their work, though partly ecological, includes lists of species from various mountains. Individual mountains have claimed the attention of other authors. Lists of the flora of Mt. Elgon have been given by various botanists, the most comprehensive being that of Bullock in Lugard's *Flora of Mt. Elgon* in the Kew Bulletin (1933). Ruwenzori is still only partially explored, and the list by Rendle and Baker (1908) is still the most complete. Others have been given by Chiovenda and Hauman. The Virunga Mountains have attracted much attention since they include a number of active volcanoes, and Mildbraed, B. D. Burtt, and Staner have dealt with various aspects of the botany. The Aberdares and Mt. Kenya were explored by the brothers R., E. and Th. C. E. Fries, and lists of the plants they collected have been published by them and others. Kilimanjaro, Africa's highest mountain, early attracted botanical exploration, and Oliver's list of Sir Harry Johnston's plants was the first important work on the flora of the mountains. The high mountain flora includes several remarkable endemic groups, and these have attracted much attention from monographers. The giant Senecios have been dealt with by Fries (brothers), Cotton, and Hauman, and the columnar Lobelias have lately been revised by Miss E. A. Bruce (1934). The results of the recent British Museum expedition to the East African Mountains will be awaited with interest.

Northern Tropical Africa

For the north tropical region the Flora of West tropical Africa (1927–36) by J. Hutchinson and J. M. Dalziel has already been mentioned, and the latter author (1937) has published an appendix to these volumes which deals with economic plants and their uses.

[1] See Chapter vii. [2] Ibid.

There are several publications on the individual British colonies. For Nigeria there is a book on the useful trees of the Northern Provinces by Lely (1925) and a forest flora of Southern Nigeria by Kennedy (1936). Holland's *Useful Plants of Nigeria* (1908 and 1922) is a valuable volume on the economic side. For the Gold Coast, Chipp (1913 and 1914) provided check-lists of forest flora and herbs, and more recently Irvine (1930) has written a valuable reference volume as a result of his work at Achimota. Sierra Leone has a work on forest botany by Lane-Poole (1916).[1] Very fine collections have been made by French botanists in their possessions in West Africa. Information regarding the floras, published by A. Chevalier and others, is rather scattered, but it is proposed in the near future to bring it all up to date in a large publication. Work is now in progress in Paris on the forest flora of French Equatorial and West Africa. For the north-eastern region, Chiovenda published many papers on the flora of Eritrea and Abyssinia, and he has recently issued a work on the flora of Somaliland. For Eritrea there is a treatise in three parts edited by Pirotta, entitled *Flora della Colonia Eritrea* (1903–1908). For the Sudan there is a useful volume published by Broun and Massey in 1929. Recently J. Gillett made an extensive collection in conjunction with the Anglo-Ethiopian Boundary Survey, an account of which will soon be published.

Some of the above are mere lists without descriptions, or with brief notes only. Workers in Africa, who have not extensive libraries for reference, need floras covering wide regions, with simple descriptions of the known species of plants and diagnostic keys for their determination. Regions for which no satisfactory works exist are (1) the eastern tropics, a flora of which has been planned by Kew; (2) the southern tropics, including the Zambesi basin, Nyasaland and the Rhodesias, and (3) the north-east tropics.

The above account is concerned only with the higher orders of plants. Much less is known in the whole continent concerning the lower plants or Cryptogams. Of these the fungi have probably been most studied. A considerable amount of systematic work on fungi has been done in South Africa, mainly by Dr. E. M. Doidge and by other members of the staff of the Division of Plant Industry,

[1] See Chapter vii.

Pretoria, and also by Prof. van der Bijl of Stellenbosch. In tropical Africa a number of collections especially of the larger fungi, have been named and lists published, notably by G. Massee and Miss E. M. Wakefield of Kew and by Mr. J. Ramsbottom and Miss Lorrain Smith of the British Museum. C. G. Hansford has recently published the first of a series of papers on the fungus flora of Uganda. The parasitic fungi which are important in connection with diseases have naturally also been dealt with (*see under* plant diseases, p. 175). A notable venture is the forthcoming publication for the Belgian Congo of an illustrated work on the larger fungi, edited by M. Beeli. This will be one of the first of its kind for any country in the tropics. As regards freshwater algae, several extensive lists have been published by the late G. S. West and also by F. E. Fritsch and Miss M. F. Rich on algae occurring in the African lakes, but, as every algologist knows, such work can be extended almost indefinitely. A list of the marine algae of South Africa by Mrs. A. Gepp was published in 1893; a more recent list is that by Dr. E. M. Delf and Mrs. Levyns (1921). For the Pteridophyta there is the volume by T. R. Sim entitled *The Ferns of South Africa* (1915), now somewhat out of date. For the tropical species there is no general work.

PLANT ECOLOGY

The study of plant ecology, particularly in relation to floristic change, deserves to be considered in some detail, since it is directly relevant to many of the problems in the spheres of agriculture and forestry, which confront Africa to-day. Professor Tansley of Oxford University has kindly prepared a list, with brief abstracts, of the more important papers on the subject. The following paragraphs are based on this list, with additions from other experts mentioned in the preface. This study is still at a very early stage of development even in Europe, where intensive work on plant ecology has been carried out during the past twenty years; in Africa a great deal of research is required before the relation of flora to environment can be known even in outline.

Perhaps the most important foundation stone of our knowledge of African vegetation is the volume by the German scientists, Engler and Drude (1908–10) on the whole continent, with special

THE EXTREME OF AFRICAN VEGETATION

Above: Tuareg in the Southern Sahara

Below: Primary tropical rain forest in Benin Province, Nigeria. The large tree is a species of Mahogany, *Entandrophragma macrophyllum.* (Photograph by Dr. P. W. Richards)

reference to the then German colonies. The later work by Shantz and Marbut (1923), already referred to in Chapter V, represents an attempt, in a sense premature, to produce a scheme for the whole continent as a working basis.

South Africa

In South Africa, after the preliminary work of Marloth (1887), Bolus (1905) and Weiss (1905) in defining the botanical regions, J. W. Bews laid the foundations of plant ecology in a long series of papers written between 1912 and 1925. These deal with the distribution of plants in relation to climate and physiography, plant succession in different types of vegetation, the thorn veld, grassland, etc. Among general studies are those of I. B. Pole Evans (1918 onwards), who contributes a chapter on plant geography in the official handbook of the Union, together with accounts of the progress made by his botanical survey; and Cannon (1924) deals with the relation of vegetation to environment in arid regions. E. P. Phillips (1931) has provided a valuable account of the grasses with three chapters on their ecology, bringing out the effects of burning, mowing and grazing; human influence is also stressed by Sim (1926), who concludes that in no locality is the flora natural. The results of burning are described and discussed by Michell (1922) and Levyns (1929a), and J. F. V. Phillips (1930a) analyses the influence of fire in changing plant successions and animal associations in both South and East Africa; his general conclusion is that controlled burning has beneficial effects on pasture-land, particularly in regions where valuable grazing would be lost if never fired; but local conditions vary so much that generalizations are dangerous. Important experiments in veld burning have been carried out recently at the Cedara School of Agriculture. Van Zyl (1926) and others have stressed the deficiency of phosphorus in both soils and vegetation. Schonken (1931) points out the results of deforestation in causing loss of water in the soil, and these and other subjects are dealt with by J. F. V. Phillips (1927, 1928a and b, 1931a), whose work may be mentioned as applying thoroughly up-to-date principles in plant ecology.

For the Cape Province, Adamson (1927 and 1931) has contributed technical ecological accounts of the vegetation of Table

Mountain; memoirs of the Botanical Survey by Muir (1930) on the Riversdale area, J. F. V. Phillips (1931b) on the Knysna region, and R. A. Dyer (1937) on the Albany region are important. Natal and the Orange Free State are dealt with by Bews (1912, 1913, 1917, 1920, 1921). Aitken and Gale (1921) describe the vegetation of Natal and Zululand, and Bews and Aitken (1923) give the results of physiological experiments on the vegetation in relation to light intensity, etc. For the Transvaal, Engler (1906) wrote an account of the vegetation, Galpin (1927) has surveyed the Springbok flats, and Mogg (1929) discussed the relationship of flora to geology in the neighbourhood of Pretoria. Furthermore Obermeyer, Schweickerdt, and Verdoorn have contributed various papers on the flora of the N. Transvaal (Annals of Transvaal Museum, Bothalia, South African Journal of Science, 1933–7). For South-West Africa there are old German works, notably by Schinz (1893), Schenk (1889), and more recently by Dinter and Range.

Southern Tropics

For Southern Rhodesia Engler (1906) first described the vegetation. J. S. Henkel (1928) gave an excellent account of the relation of vegetation to water-supply, and (1931) described the types of vegetation in relation to other physical features such as geology, soils, winds, rainfall and temperature, and in the same publication produced a reliable vegetation map of the territory. In relation to this work H. B. Maufe (1915) has described the Rhodesian soils and their origin, as noted in Chapter V. For the neighbourhood of Salisbury, where overgrazing has altered the natural flora materially, F. Eyles (1927) has contributed ecological notes of value. In 1930 General Smuts and Dr. J. Hutchinson made an extensive collection during the dry season from the Limpopo to Lake Tanganyika, the results of which will appear in the latter's account of his tour in South Africa.

In Northern Rhodesia the distribution of vegetation has been studied locally through the medium of air photographs. R. Bourne (1928) has provided a list of the vegetational types encountered in air survey, and found them coincident with soil colour and geological formation in certain zones. E. Milne-Redhead in 1930 accompanied the ground control party of the aerial survey in Northern

Rhodesia and reported to the Colonial Office on the use of air photographs in botany and forestry (not published). Ecology from the air has also been exploited by C. R. Robbins (1934); although an air surveyor himself, he realizes the limitations of the method, and has produced a valuable contribution. The official ecologist in Northern Rhodesia, C. G. Trapnell, has obtained valuable results working on the ground, and has also used air photographs to advantage; his results are published as appendices to the annual reports of the agricultural department for 1933 and 1934, and with J. N. Clothier (1937) he has published a detailed account of the survey incorporating soil and vegetation maps. These link up with that for Southern Rhodesia by Henkel. For Nyasaland, Topham (1930) has considered the effects of agriculture in relation to forests.

Little has been published for Angola or Mozambique beyond the systematic works referred to on page 155. Gossweiler has given a short sketch of the botanical regions of Angola; and is also preparing a very complete phyto-geographical map of Angola. Burtt Davy (1931) has produced a brief account of the forest vegetation for the whole of this region.

Central Tropics

There is a considerable amount of literature bearing on the ecology of Kenya and Uganda, but study has been seriously hampered by the lack of a flora for the determination of species. Most of the common weeds can only be determined by workers in Africa to species which are manifestly composite, or even to genera. The following work may be mentioned: Snowden (1933) has studied altitudinal zonation on the Bufumbira volcanoes and the adjoining Kigezi district in Uganda. Burtt (1934) has carried out a study of the same region, and several other writers have described the altitudinal zonation of Ruwenzori, Elgon, Kenya, and other mountains. Mildbraed's (1922) important account of the German Central African Expedition of 1907–8 deals mainly with rain forest, and Dawe (1906) has also studied the forest districts of Uganda. J. W. Nicholson (1929), in considering the influence of forests on climate and water-supply in Kenya, concludes that in certain regions the total rainfall is likely to be affected by changes

in vegetation-covering; in his view the mountain forests may induce occult precipitation in the form of dew and mist, not measureable by the usual methods, up to 25 per cent of the total rainfall, and wherever meteorological conditions tend to instability, forests greatly increase the possibility and quantity of rain. Graham (1931) has given notes on the mangrove swamps of the Kenya coast.

In general, there has been so much interference with vegetation by man in East Africa, that in Uganda, for instance, scarcely any of the original vegetation may be seen below an altitude of 7,000 feet, the grasslands, swamps and forests being nearly all secondary growths. Hence plant ecology is peculiarly difficult to interpret. Eggeling (1935) has published a paper on the ecology of swamps, which are so marked a feature of Uganda.

In Tanganyika the vegetation of Mt. Kilimanjaro has been described in several German books, notably Meyer (1891) and Volkens (1897), and more recently by Cotton (1930). Engler (1894) described the vegetation of Usambara in an early work. J. F. V. Phillips, when botanist in the department of tsetse research, was perhaps the first to apply modern principles of ecology. He has described (1930b) the principal vegetation communities and successional relations in the Central Province of Tanganyika and (1931c) has outlined the floral regions. On this P. J. Greenway (1933) and J. D. Scott (1934) have based detailed studies in the more accessible parts of the territory.

For the Congo Professor de Wildeman has written extensively on vegetation, especially in 1912, and in his work of 1926 on the Congo forests. He holds that fire has been the principal factor in limiting forest country, a view with which his successor at the Brussels Botanical Gardens, Dr. Robyns, does not entirely agree. Robyns (1930) has published a survey of the vegetation of the Congo with a small map showing distribution. He has also studied (1932) the revegetation of the lava fields of the volcano Rumoka (Kivu), and Professor Hauman (1933a) has outlined the alpine and sub-alpine vegetation of Mt. Ruwenzori. In Kivu, extensive researches on the relation of the mountain vegetation to the climate, and especially water-supply have been made by H. Scaëtta (1933). For the Katanga G. Delevoy (1928) has published an ecological

description of the main regions, and discussed the role of forests in development. Lamy (1933) has studied the forest land of Ruanda-Urundi. Lebrun (1932) has surveyed the Ubangi district and (1936) has summarized all the botanical work on the Congo forest flora up to that date.

North Tropical Africa

The work of the late Dr. T. F. Chipp, when Conservator of Forests on the Gold Coast and subsequently at Kew, stands out pre-eminent, especially his analysis of the Gold Coast forests (1927), an analysis of the tropical forest from the modern successional point of view. Chipp wrote also two general papers (1930 and 1931) analysing the vegetation over much of north tropical Africa. Professor P. A. Buxton (1935), when working on tsetse flies in northern Nigeria, gathered interesting data on the relation of climate to seasonal changes in vegetation. W. D. MacGregor (1934) silvicultural research officer in Nigeria, has shown how closely ecology and silviculture are related in that country, with especial reference to the mixed deciduous forest.

For the French territories A. Chevalier (1912) has produced a useful vegetation map of the whole of West Africa on the scale 1:3,000,000, and A. Meunier (1923–33) of the Ministry for Colonies, Paris, a series of six economic maps of French West Africa on the same scale. Four of these deal with vegetable resources, one with wild fauna and one with domesticated animals. Chevalier (1933) has summarized the botanical regions of all north-west tropical Africa. L. Lavauden (1927) has recorded much evidence concerning the degeneration of vegetation, which is thought by many to be the result of progressive desiccation, rather than of human activities. He considers that though protection may win back some of the vegetation, the Sahara will continue to advance. O. Hagerup (1930) has made a useful study in the Timbuctoo region of the Sahara: the distribution of plants was found to be remarkably uniform since their general method of dispersal is by wind. R. Maire (1933 and 1935) has described the flora of the Central Sahara and Tibesti Mountains in two long papers, the results being discussed by Hutchinson (1936). For the Cameroons, J. M. Dalziel (1930) studied the flora of the high mountain region

and found it to be closely similar to that of the East African mountains, and J. Mildbraed (1930) has given an accurate enumeration of rain forests, one of the few works of its kind yet published for Africa. M. Aubréville (1932), chief of the forestry service in French West Africa, has produced a full account of the different types of forest, rain—deciduous—mangrove, etc., and their distribution in the Ivory Coast.

For the Abyssinian flora C. L. Collenette (1931) has given a general physiographic account, and J. Gillett, who accompanied the Somaliland-Ethiopian Boundary Commission of 1933–4 as botanist, will be publishing shortly on both British Somaliland and Abyssinia.

Swamp vegetation and water-supply

It is difficult to select any particular aspect of plant ecology for special attack, but it may be stressed that the most immediately useful results can be achieved by the exhaustive survey of restricted types of plant habitat. Attention may be directed, for instance, to the vegetation of swamps which has a most important role in the natural economy in many parts of Africa.

From one point of view swamps seem responsible for great loss to Africa in that they soak up and evaporate water which might otherwise be utilized. It is estimated that the sudd areas of the White Nile together with the papyrus swamps around Lakes Kioga and Victoria are responsible for the loss by transpiration of some 50 per cent of that river's water. Hence large-scale engineering work is proposed to short-cut the sudd area and thus increase the supply of water from Central Africa to the Sudan and Egypt (see Chapter II).

On the other hand, some authorities consider the swamps to be the most important natural water-reservoirs of Africa. If the swamp plants are destroyed, the swamps and vleis will disappear and the streams which rise from them will become intermittent or cease to exist. From this point of view the preservation of swamp vegetation is as important as that of forests.

Clearly there is here a problem calling for intensive research on the exact part played by swamps in hydrology, and the probable results of draining swamps or cutting the vegetation. It has some-

times been suggested that papyrus and other swamp plants could be used to produce paper or possibly power alcohol. Some years ago a factory was actually opened in the Sudan with this in view, but was closed down soon afterwards; and in 1931 the late Dr. Chipp reported (not published) to the Sudan Government at considerable length on the possibilities of a paper factory. Extensive investigations were also made in the sudd area in 1929 and 1930 with special reference to the proposals for canalization, by N. D. Simpson, a botanist seconded from the Egyptian service. He also has reported (not published) to the Sudan Government. The only other study on the plant ecology of swamps in Africa appears to be that by Eggeling (1935) on the Uganda swamps referred to above. The Cambridge Expedition to the East African Lakes of 1930–1 paid some attention to swamps, and among its reports L. C. Beadle (1932) has described the bionomics of some swamps, particularly in relation to physical and chemical conditions. In South Africa D. Weintroub (1933) has described the aquatic and subaquatic vegetation of the Witwatersrand.

TOXICOLOGY AND MEDICINE[1]

A special branch of botanical study is that of plant poisons and medicinal herbs in use by natives. Accounts of such plants have been given for South Africa by Professor J. M. Watt (1932) and Dr. D. G. Steyn (1934). These two books and various papers by the same authors form the basis for further work of this nature in Africa. Professor Watt's volume deals with the medicinal uses, chemical composition and toxicology of plants in relation to both man and animals, and includes a survey of all previous work on these subjects. Dr. Steyn's book is based on work at the Onderstepoort veterinary research station, where a team of scientists have been investigating all aspects of animal diseases due to plant poisons for many years. The book deals critically with the fundamental as well as the specific aspects of plant poisons, and gives a systematic account of all the known poisonous species which occur in South Africa. For Uganda, Mettam (1932) has written an account of plants poisonous to stock.

Of French scientists, R. Dubois (1933) has discussed some of the

[1] See also minor forest products, Chap. vii, p. 209.

medicinal plants of the French Sudan, and G. Ivanoff (1936) has given an account of those used by the inhabitants of the Ivory Coast. For the same territory R. Portères (1935) has described plants from which poisons are obtained for hunting, fishing, warfare and criminal purposes. For the Belgian Congo de Wildeman (1935) has described all plants known to be used as medicinal drugs, much of the information being obtained by the staff of the FOREAMI working in the Congo (*see* Chapter XV). For Nigeria, the Gold Coast, and neighbouring territories, Dalziel's volume entitled *The Useful Plants of West Tropical Africa* (1937) is important since special attention is given to the medicinal plants. As very few derivatives from African plants are mentioned in the British Pharmacopoeia, there would seem to be scope for research of an interesting nature.

PASTURE RESEARCH

A large part of the African continent is at present of value to man primarily for raising stock, and is likely to remain so. Moreover, if the tendency to soil exhaustion already noticeable in some regions becomes further exaggerated, certain areas which are now regularly cultivated may have to be laid down to pasture in order to keep a permanent protective cover of vegetation. Hence the improvement of pastures, both natural and artificial, has become important. This work can be divided into the study of the constituent species of pastures, whether grasses, clovers, or other kinds of plant; the suitability of different kinds to the various environments; the nutritional value of different kinds; and the breeding of pure strains of grasses and legumes suitable to special conditions. These branches of pasture research are still mainly in the experimental stage, but in recent years the problems of soil erosion, nutrition of domestic animals, and drought, have stimulated governments to employ specialists in several areas. In spite of the contribution that botanical science can make, it must be remembered that the proper management of natural and artificial pastures is dependent on adequate facilities for watering stock, and hence attention must be directed again to the importance of investigations on water-supplies, a subject discussed in Chapter III.

The identification of the species occurring in the grasslands of tropical Africa is based primarily on systematic research carried out at Kew. The main results have been published by the late O. Stapf and later by C. E. Hubbard in volumes nine and ten of the *Flora of Tropical Africa* (which deal exclusively with grasses), and also in papers in the *Kew Bulletin*. In addition, lists of determinations and notes on individual species are supplied by Kew to departments of agriculture, agricultural institutions, and agricultural workers, not only in the British territories, but frequently also to correspondents in non-British countries. Two illustrated booklets on East Tropical African grasses by C. E. Hubbard (1926–7) are useful for veterinary and agricultural officers. The identification of South African grasses, mainly in connection with pasture research, botanical survey work, etc., is dealt with as far as possible by the botanists attached to the National Herbarium, Pretoria, or by the South African liaison officer stationed at Kew.

The Imperial Bureau of Plant Genetics (Herbage Plants) at Aberystwyth, directed by Professor R. G. Stapledon, is a centre for the collection and dissemination of information on all questions relating to grasslands and forage crops. The information is supplied in the two quarterly Journals, *Herbage Abstracts* and *Herbage Reviews* and in bulletins, which are issued as material accumulates. Centred also at Aberystwyth is the Welsh Plant Breeding Station, where research workers, led by Professor Stapledon, have developed the application of genetics to pasture research and have shown how the nutritive value of practically any natural pasture can be improved to a remarkable degree by planting specially bred strains of grasses, with suitable subsequent management in the way of manuring and controlled grazing. The Imperial Bureau and Professor Stapledon's research department work in collaboration with the Imperial Bureau of Animal Nutrition and the Rowett Institute at Aberdeen, under Sir John Orr's directorship, in connection with the nutritive value of pastures. Deficiency in the mineral content of pasture plants is known to cause disease of stock, and this subject is of such importance that in 1925 a sub-committee of the Committee of Civil Research, which in 1930 became a Committee of the Economic Advisory Council, was instituted 'to consider and

report on the mineral content of natural pastures'. Sir John Orr visited South Africa and Kenya on behalf of the committee and, on his recommendation, the Government stock farm at Naivasha in Kenya was selected for exhaustive experiments. An account of Sir John Orr's work in East Africa was published by the Economic Advisory Council (1931).

In *South Africa* similar work on the nutritive value of pastures and deficiency diseases of stock has been carried on at Onderstepoort for the last thirty years, and much material has been published. This work has led directly to the effective control of several diseases, for example, the discovery by Sir Arnold Theiler and his collaborators that Jaagsiekte in horses, etc., are all due to poisonous plants common in natural herbage. Again, Theiler's discovery that Lamsiekte in cattle is caused by bacteria of the *Botulinus* group, and that infection results from animals chewing bones in order to make good the phosphorus deficiency in natural pastures, is now a classic in veterinary science. Recently work on pasture improvement has been stimulated by the opinion now prevalent that 'breeding must go in at the mouth'.

The history of pastures and pasture studies in South Africa, with suggestions as to future tendencies, has been written by T. D. Hall (1934), and an up-to-date summary of results has been published by the Imperial Bureau of Plant Genetics (1937). A number of grasses have been introduced to South Africa from other parts of the continent and elsewhere; notable among these is Teff-grass (*Eragrostis teff*), which was introduced by Dr. Burtt Davy to the Transvaal as early as 1903. Grown as a hay crop it has proved of the greatest value in the drier parts of South Africa, as described by Burtt Davy (1916). Exotic pasture grasses have not been successfully introduced except for the purposes of winter feed, so research has been directed to the selection of the most suitable of the indigenous species. This has been carried out mainly by the Division of Plant Industry of the Union Department of Agriculture under Dr. Pole Evans, who has published a summary of results (1933).

The woolly finger grass, consisting of various species of *Digitaria*, is pre-eminent in carrying capacity, and is richer in minerals, protein and carbohydrates than any other. Possessing stolons and the

capacity for rhizomatous spread, it resists drought and heavy grazing better than species with superficial roots. By the end of 1933 one hundred and fifty stoloniferous strains of *Digitaria* were under trial; some are showing suitability for general grazing, others for mowing, others which stand covering by blown sand are suitable for arresting erosion, still others are peculiarly resistant to drought. In addition a number of other indigenous grasses, such as elephant grass (*Pennisetum purpureum*), which is particularly suitable for fodder and ensilage, Rhodes grass (*Chloris gayana*), Kikuyu grass (*Pennisetum clandestinum*) and Limpopo grass (*Echinochloa pyramidalis*) have been introduced to the Union from the Rhodesias, Kenya, and other parts of the continent, but as yet the selection and hybridization of pure strains has been carried out only with *Digitaria*.

The headquarters of this work are at Pretoria, where the experimental stations have collections of growing pasture plants representing numerous genera, species, and strains. In addition the Universities of Pretoria, the Witwatersrand, Capetown, and South Africa receive special grants from the Department of Agriculture for work bearing on veld control, and other special studies are carried out at the several schools of agriculture; the management and renovation of veld is being studied by the school of agriculture, Potchefstroom; grass-burning and grazing in natural and cultivated pasture by the Cedara school of agriculture, Natal; manuring and grazing in controlled plots and cultivation of fodder crops, especially lucerne, by the Grootfontein experimental station C.P.; rotational grazing and regeneration of pasture by the Glen experimental station, Orange Free State; and the grazing value of karoo bush and other fodder plants at Fauresmith.

The Botanical Department of the Witwatersrand University is concentrating on the fundamental ecology of veld; results should throw light on the balance of the native species of grasses and other herbs and on their reactions to grazing, fertilization, burning, etc. A Grassland Research Committee, formed from Pretoria University and African Explosives and Industries, Ltd., has published (1932) a useful general review of the situation in South Africa, bringing all research into line. R. Lindsay Robb (1936), Chairman of the Committee, has produced a sequel report with the

principal object of placing the results of experiment at the disposal of South African farmers.

In *Southern Rhodesia* the Division of Plant Industry has also been concentrating on pasture improvement, and a detailed experimental plan has been made out to test indigenous grasses and leguminous plants. It is described by Graham and Hall (1933). The systematics of grasses in Southern Rhodesia are fairly well known through the work of Stapf and later through papers published by Miss S. M. Stent and J. M. Rattray (1924 and 1933), so that the field is now open for ecological and experimental studies.

In the Northern part of the *Anglo-Egyptian Sudan* studies have been made on the irrigation of pasture-land, and several species of grasses, both African and Australian, have been tried without very satisfactory results. In this connection research in Australia has indicated that European pasture plants can be maintained in subtropical areas if the system of irrigation is properly adjusted. Contouring of the land is necessary, while the frequency of watering and the facilities for adequate drainage are important. Much of the southern Sudan is covered with tall rank grasses of little value for grazing. A short, close-growing pasture capable of keeping down this natural vegetation would be invaluable.

In the territories under the Colonial Office, little experimental work has been undertaken, but in several areas the ecological aspects of grazing, firing, and manuring are being studied. There are now officers devoted entirely to pasture work in Tanganyika and Kenya, and attention is being paid to the chemical constitution of grasses in several of the veterinary laboratories.

In *Northern Rhodesia* there is no whole-time pasture expert, but studies on grasslands have been undertaken by the ecologist, C. G. Trapnell (1932 and 1933), who points out that research is required on the following subjects: 1, cutting for the purpose of breaking-in tall grassland; 2, rotational grazing in order to increase stock yield; 3, sowing grass on maize lands intended for abandonment; 4, harrowing and propagation for reclaiming eroded pastures. Results to date, which are suggestive rather than conclusive, have been published in order to make a permanent record of the initial progress. Trapnell refers primarily to problems of manage-

ment in thorn country and sweet bush grasslands, and concludes that rotational grazing in paddocks and extensive mowing would improve the veld and prolong the nutritive value of the natural grass to such an extent that cultivated pasture would be unnecessary. H. B. Stent contributes valuable data on seasonal changes in the chemical composition of pasture grasses.

In *Tanganyika* the problems have been briefly stated by R. R. Staples (1934), the pasture officer, and the annual reports of the Department of Veterinary Science and Animal Husbandry for 1933, 1934, and 1935, have sections by him on pasture research and also results of chemical analyses of grasses by M. H. French, the biochemist. A reference herbarium for the difficult task of identifying the local grasses is being collected by Capt. Hornby, Director of the veterinary department, and Mrs. Hornby, with the co-operation of the botanist at Amani. Introductions have been made from South Africa, Southern Rhodesia, Australia, and India, while grazing trials on acre paddocks of various indigenous African grasses are in progress at Mpwapwa, the headquarters of the veterinary department.

Staples has recorded the grazing conditions in several districts during the past few years, in order to gauge as accurately as possible any vegetation changes in the pasture which may result from increases in stock. Conditions in the Ngorongoro crater on the edge of the Serengeti plains are of particular interest. Though little more than one hundred square miles in extent, it is estimated to carry upwards of eighty thousand head of game, besides some twenty thousand Masai cattle for six months of the dry season. All the kinds of game are maintained in excellent condition until the very end of the dry season. As a pasture area the crater is of special interest in that grazing seems to be the chief factor in maintaining the dominance of the grasses. The astonishing carrying capacity is partly due to fertile soil conditions, but above all to the annual resting of the pastures when the game migrates in the wet season, combined with heavy manuring by droppings. It is therefore a valuable natural demonstration of the benefits of resting and manuring pastures. In Tanganyika an inquiry is also going forward regarding the transpiration rates of plants, since local indications suggest that in the conservation of water-supplies it may be

more profitable to encourage grass than forest in view of the high transpiration rate of the latter.

In *Kenya* a general study of pasture species is in progress. Mr. Edwards, the officer in charge of grassland improvement, has for two years past been stationed at Kabete, at the veterinary research laboratories. He has concentrated on the local indigenous grasses and legumes, and an ecological survey of the main climatic types of grassland is being undertaken as facilities permit. The grasslands of Kenya (Edwards 1934) fall into three main divisions: (a) areas of high moisture and low temperature, and 6,500 to 10,000 feet altitude, (b) intermediate areas, and (c) dry areas. Studies of the first two are in progress at Kabete with extensions in various parts of the colony, and the nutritional research station at Naivasha in the rift valley is a centre for the dry areas. At Kabete are established pasture-plant nurseries, especially for Kikuyu grass, plots for seed production, and other plots for raising mixed pastures, legumes, including *Lespedeza* from America, and fodder crops, manure trials, etc. Experiments made include palatability and grazing trials for each strain raised. At Naivasha drought-resistant species and manures are under trial, and experiments are in progress on the renovation of pasture depleted by locusts, drought, and overgrazing. Already this work has yielded information of direct practical application over considerable areas at the higher altitudes, as shown by Edwards (1935); for the intermediate areas Rhodes grass has proved suitable for sowing down for pasture and hay, and for the drier areas methods of controlling overgrazing, based on the natural plant succession, have been suggested.

In *Uganda* and *Nyasaland* little pasture work has been started, since the grasslands have not yet been affected by heavy grazing to a serious extent. The increase in stock is threatening, however, to make action necessary.

In *British Somaliland* Mr. R. A. Farquharson, agriculturalist and geologist, has devoted considerable sections of his recent reports (not printed) to the reconditioning and improvement of natural pastures. It appears that much of the scant vegetation has been destroyed by overgrazing. Since much of the surface soil contains deposits of brak, the South African salt-bush, a useful grazing shrub, is to be introduced for trial.

In *Nigeria* work on grasses was not started till 1932, since when data, chiefly on chemical aspects, have been collected and are summarized by Anderson (1933). Work is being done on possible fodder crops to tide over the dry season when cattle grow thin as a result of the reduction in nutritive value of the parched grasslands.

In the non-British territories little work has yet started on the subject except in a few areas, chiefly because the problem of overgrazing is not acute. Chevalier (1933–4), however, has published a preliminary study of the grasslands and grasses of the French territories. In *French West Africa* work on pasture plants is carried on at several stations: at El Oualadji in the Sudan, research is concerned with the feeding of sheep, at Soninkoura the Office du Niger studies the pasture plants of the irrigated areas, while at Sotuba the suitability of plants for introduction to the Sudan area has been tried. Interesting results have been obtained with plants introduced from South Africa, the Belgian Congo, America, and India. Rogeon (1932) has discussed the forage grasses of the French Sudan with regard to their agricultural possibilities. In Morocco grasses from the southern parts of the continent have been introduced with success, particularly Napier, Rhodes, and Kikuyu grasses.

In the *Belgian Congo* study of the taxonomy of native grasses is well advanced as a result of the monograph being prepared by Dr. Robyns, which will serve as a foundation for research on pasture improvement in the future. Already erosion from excessive grazing has been noticed in Ruanda-Urundi, and the recent introduction of five thousand head of cattle from Ruanda to Katanga will probably necessitate study of the pastures there. In another publication Robyns (1931) has suggested using indigenous grasses for the improvement of pasture-lands, and experiments with this end in view are now being carried out by the veterinary service of the Congo and by the Comité Spécial du Katanga. The destruction of forest trees in several places in the Congo, as in other parts of the continent, has led to the formation of grassland which is of little value for grazing, consisting in the main of the grasses *Cynodon dactylon* and *Paspalum dilatum*, and frequently overrun with *Panicum*. Many farmers have introduced Kikuyu grass

(*Pennisetum clandestinum*), but on the Nioka government stock farm the grass is no longer much cultivated both because it is insufficient to support a larger head of stock, and because a diet of Kikuyu grass alone has been found to lead to reduced milk production. At Kerekere experiments are in progress with many kinds of forage plants to ascertain which are the most suitable to local soil conditions, and the department has analysed many samples of grass from every pastoral district in the Congo (Congo Belge 1935). Some of the results are given in a long paper by H. Scaëtta (1936).

The extensive researches carried out in Australia at the Waite Institute have produced results directly applicable in Africa, and exchange of grasses between the two continents has been made during the last few years. The results so far are inconclusive. It is possible that the methods of research evolved there may also prove applicable throughout Africa, particularly in connection with studies of leguminous plants, on which little is at present known in Africa. Knowledge of these, especially clovers, is a necessary aspect of pasture research, since the ability of pasture to maintain soil fertility depends principally on the legumes.

PLANT BREEDING AND PLANT PATHOLOGY

Studies of plant breeding and plant pathology are directed mainly towards the improvement of agricultural crops, but wild forest trees have also received some attention from pathologists. Together they absorb the greater part of the botanical effort which Africa is able to put forward.

In plant breeding striking results have been achieved in producing improved varieties of crops both for export and for internal consumption. The three desiderata of increased yield, better quality, and resistance to disease have sometimes been combined successfully. This work will be considered together with agricultural methods in Chapter XII. For truly scientific plant breeding fundamental studies in genetics and cyto-genetics are necessary. Little provision for research in these subjects exists so far; there are as yet only two professorships of genetics in the United Kingdom, and the number of expert geneticists is correspondingly few. Until this science develops, plant and animal breeding experi-

ments for practical purposes must depend largely on methods of trial and error.

Diseases of plants are caused by insects, nematode worms known as eel-worms, fungi, moulds, and viruses. In addition, certain deficiency diseases are known to be caused by lack of nutrients in the soil. The effects of insects, both as direct agents in causing disease and as vectors of viruses, etc., are considered in Chapter X; most of the other diseases are dealt with in Chapter XII, and certain diseases of trees are mentioned in Chapter VII. A few general remarks on the botanical side of pathology are suitable here.

Cotton, as one of Africa's most important cash-crops, has been subject to more botanical work than any other plant, both with a view to the improvement of strains, and the control of disease. The bacterial disease known as black-arm, caused by *B. malvacearum*, has received particularly intensive study. Notable workers on this subject have been Massey in the Sudan and Hansford in Uganda.

On virus diseases of plants striking researches have been carried out by the plant pathologist at Amani, Dr. H. H. Storey, who is recognized as a leader in this field. On fungus diseases a considerable amount of work has been carried out both in tropical and South Africa, the diseases of the most important crops having, naturally, received first attention. In South Africa most of the published work has been by Dr. I. B. Pole Evans, Dr. E. M. Doidge, and Professor van der Bijl. With regard to the tropics, Mr. R. H. Bunting and Mr. H. A. Dade, who formerly worked as mycologists in the Gold Coast, have published much, particularly on the moulds which affect cocoa and other stored products. Moulds are not well understood, but in the Gold Coast a number of strains have been isolated and their reaction to artificial conditions has been investigated. In general, the limiting factor to their growth seems to be humidity. W. Small and C. O. Farquharson did pioneer work in Uganda and Nigeria respectively. A preliminary list of fungi and plant diseases in Sierra Leone has been produced by Deighton (1936) and one for Tanganyika has been published by G. B. Wallace (1932 and 1936); J. C. Hopkins has published a list of plant diseases in Rhodesia, and other such lists are in preparation under the auspices of the Imperial Institute of Mycology.

Diseases caused by rust fungi are important. Those which affect grain have been studied specially in South Africa by Dr. Pole Evans, and in Kenya, where McDonald's work is noteworthy. Some success has already resulted from attempts to breed strains of wheat resistant to these diseases. The coffee rust fungus, *Hemileia*, is under investigation at Amani. For all these studies the Imperial Institute of Mycology at Kew is now the centralizing headquarters for information and research.

PRESERVATION OF FLORA

The preservation of the indigenous flora is an aspect of botany which perhaps deserves more attention than it has received in connection with the development of national parks and nature reserves. The vegetation of Africa is changing very rapidly, not so much in the sparsely populated inland plains, where vast areas are still unaffected, but in the more densely populated regions, which are subject to influences such as shifting cultivation,[1] the introduction and spread of exotic food-plants, and afforestation with exotic trees. Even the introduction of foreign plants into gardens may have unexpected results. This is the case particularly with fast-growing trees such as wattles and gums which multiply very rapidly under favourable circumstances, and dispossess the indigenous trees and shrubs.

It is necessary also to consider the provision of reserves for the indigenous flora in addition to forest reserves. Such areas need not be very large, but if they are to have their full educational value they should be situated in accessible places. Under suitable management they could with advantage be made to serve the purpose of botanical gardens. A resolution urging the maintenance of representative areas of forest in their primeval condition was passed at the Empire Forestry Conference in South Africa in 1935. In parts of South Africa, action has already been taken: nature reserves have been established by the Department of Agriculture and Forestry where no planting of trees, no grazing, and no destruction by fire will occur. Some of these are areas of macchia-like vegetation, notable for their beautiful plants, and others are

[1] See Chapter vii, p. 187 and Chapter xiii, p. 376.

in regions of virgin forest, such as the Lily Vlei Nature Reserve in the Gauna Forest near Knysna. In a recent report on forestry in Tanganyika, Professor R. S. Troup (1936) has emphasized the desirability of forming nature reserves of this kind in that territory, and has suggested definite areas for the purpose. Another botanical reserve of great value is the Parc National Albert in the Belgian Congo, which will preserve the mountain forests, as well as the subalpine and alpine flora of the volcanoes in the neighbourhood of Kivu.

At the recent international conference on the preservation of African fauna and flora (1934) a list was made of particular plant species threatened with extermination: one plant only, the famous *Welwitschia*, a member of the coniferous group, but showing remarkable affinities with the true flowering plants, was placed in class A, as warranting complete protection. The wider aspects of the subject were little discussed, and it was decided that the reservation of areas where exotic plants would not be allowed was the only practical step to be taken. It is to be hoped that during subsequent conferences on the subject more attention will be paid to the flora. 'As the primeval forest is destroyed the ancient verdure of the earth is lost for ever. The trees depart in flames and no mantle descends to clothe our ignorance.'

CHAPTER VII

FORESTRY[1]

INTRODUCTION

THE problems of forestry are linked with those of agriculture, since any forestry policy must be considered in relation to the various demands made by man on the produce of the soil; in African conditions native cultivation over large areas depends directly on the distinction of forest growth. The subject is so closely bound up with those of plant ecology and systematic botany, dealt with in the last chapter, that it is most convenient to discuss it at this stage.

The condition of the forests affects, directly or indirectly, the water-supplies, the fertility of the soil, fuel and timber supplies for domestic and industrial use, and the possibilities of agriculture for subsistence as well as for export. The importance of the forests in the general economy of Africa has two aspects, that of the economic utilization of forest products, and that of the conservation of water-supplies and soil, the relative importance of which varies with the character of the country. In the more arid tracts the forests are coming to be valued primarily for their role in water conservation, whereas in the belts of rain-forest, where land once cleared is rapidly covered by dense vegetation, the productive aspect is regarded as more important. A hard and fast division, however, is impossible.

Before the position of forests in relation to rainfall can be fully understood, much research is necessary in the subjects of meteoro-

[1] Professor R. S. Troup, when Director of the Imperial Forestry Institute at Oxford, and members of his staff, notably Mr. Ray Bourne and Dr. J. Burtt Davy, kindly prepared a special memorandum for the African Research Survey on Forestry in Africa, mainly devoted to the British territories. This formed the basis for a first draft of this chapter, which has been re-written in the light of new information and after circulation to the experts mentioned in the Preface.

logy and plant physiology, particularly in relation to the transpiration stream of growing trees, and the amount of moisture added to the atmosphere by a forest area of a given type. Until such data are available, it appears essential to preserve areas of forest land at least sufficient to ensure the continuation of present water-supplies and to avoid soil erosion. This necessity is usually met by the establishment of areas of reserved forest (which need not, of course, be closed to commercial exploitation) on high ground, especially in the neighbourhood of watersheds. The principal object is to ensure that the streams and rivers are maintained as perennial and not reduced to mere intermittent floods, as would be the case if forest growth were removed and the soil eroded.

In many parts of Africa, especially where native agriculture is based on shifting cultivation, the destruction of forests has gone beyond the safety limit. It has been difficult to enlist the support of native administrations in the creation of forest reserves, owing to their failure to appreciate the necessity of measures which may involve a diminution in immediate revenue.

Another matter in which it appears that stricter control is desirable is in the grant of concessions to mining companies to cut forests for timber and fuel. There are conspicuous examples in the Gold Coast where such concessions, granted forty or fifty years ago, have led to large-scale destruction of evergreen forest around mining areas, and there appears to be no organization for replanting. With the rapid development of mining in other parts of Africa, especially in Northern Rhodesia, Tanganyika and Kenya, there is danger that this situation may be repeated on a large scale. Since a supply of timber is essential for mining operations, it would seem that provision for the replacement of forest destroyed is desirable.

ORGANIZATION

BRITISH

The central institutions in Great Britain which deserve mention are as follows:

The *Imperial Forestry Institute* at Oxford, now under the direction of Mr. J. N. Oliphant, is the Empire centre for advanced training

in forestry. It forms part of the Department of Forestry at the same University, under Professor R. S. Troup, which is the most important training centre. Its members visit African territories from time to time; thus Professor Troup has studied the forests of Kenya, Uganda and Tanganyika; Mr. Oliphant visited South and West Africa before taking up his appointment; Dr. Burtt Davy has wide experience in the Transvaal and other parts of Africa, and is the leading British authority on forest botany, so that Oxford has become a centre for the identification of Empire trees and woods. At the Empire Conference of 1935, a resolution was passed to the effect that the institute could be of still greater value to Empire forestry if it were more fully staffed and financed for research. Since few African administrations can employ a staff of specialist forestry officers sufficient to study all the problems which arise, it was suggested that with greater financial support the institute might maintain a staff of research workers who could undertake short terms of intensive work, as required by the different territories.

The *Colonial Forest Resources Development Department*, with Major F. M. Oliphant as Forest Economist, was formed in 1936. It is in close relation with the *Forest Products Research Laboratory* at Princes Risborough, a research establishment of the Department of Scientific and Industrial Research, which was enlarged in 1930 as a result of a Government grant of £30,000. This station is concerned with research on wood and wood products, and undertakes the testing of Empire timbers, determining their properties and bringing them to the notice of manufacturers. While the Empire Marketing Board existed, testing was done free for the colonies, but now a charge is made which makes it difficult for the smaller colonies to make full use of the laboratory. Major F. M. Oliphant has recently made two visits to the West African colonies and another to East Africa to study and report on the forestry situation, particularly with a view to improving the preparation of woods for export and developing closer co-operation between producers and manufacturers (Oliphant, F. M. 1934a and b, 1935, 1937).

The *Imperial Institute Advisory Committee on Timbers*, which is composed of voluntary members of the wood-using professions and trades, has done valuable work in advising on the development of

trade in new timbers, examining samples and arranging trade trials. For the Colonial Office the newly formed Colonial Forest Resources Development Department has taken over most of this work, but its members co-operate with the Imperial Institute Committee.

In Africa itself there are special forestry organizations in the Union of South Africa, Southern Rhodesia (a division of the department of agriculture and lands), the Anglo-Egyptian Sudan (a section of the department of agriculture and forests), and separate forestry departments in the British colonies, protectorates and mandates, except in Northern Rhodesia where there is a forestry branch of the agricultural department, and the Gambia. The staff of each department is shown in the following list:

FORESTRY STAFF
(British Territories)

Territory	*Total European forestry staff*[1]
Union of South Africa	272
Southern Rhodesia	16
Northern Rhodesia	4
Nyasaland	6
Tanganyika	17
Kenya	23
Uganda	11
Nigeria (including British Cameroons)	51
Gold Coast (including British Togoland)	23
Sierra Leone	4
Anglo-Egyptian Sudan	8

The *Union of South Africa* has the oldest and largest forestry organization. The Division of Forestry, under the general direction of the Secretary for Agriculture and Forestry, consists of four sections: administrative, forest management, silvicultural research, and the Forest Products Research Institute. The latter, situated at Pretoria West, renders the Union independent in experimental work on the utilization of timbers. The organization is outlined in full in the statement made to the British Empire Forestry Conference in 1935 (Union of South Africa 1935). In South Africa a course of higher training in forestry has recently been opened at

[1] Compiled from *Empire Forestry Handbook* (1938).

Stellenbosch University, while there is a training school for subordinates at Saasveld, George, C.P.

In the *Colonial Forest Service* in Africa very few officers are engaged solely in research, but in a sense most forest officers are potentially research workers in that they gather data in stocktaking and similar duties. Their activities are, however, devoted largely to administrative work. Nigeria appears to be the only territory where a permanent research branch of four officers is maintained. All African departments have recognized the irrevocable consequences of the destruction of forest and their attention is accordingly devoted mainly to the reservation of forest areas and the collection of revenue.

Some 90 per cent of forest officers entering the colonial service as probationers are university graduates who have had a year's special training at the Imperial Forestry Institute. As some authorities have maintained that in spite of this training only a small proportion have the ability and qualifications for fundamental scientific research, it has been decided that the post-graduate training should be given to the probationer after, rather than before, his first tour of a colony, when he has some experience of the type of problem confronting him. For specialist research, the organization of workers under the Imperial Forestry Institute, as suggested above, appears to offer the best prospects, particularly for the use of the smaller colonies.

In no colonial territory does the forest department regularly undertake the extraction of timber: this is handed over to private enterprise, which, as a rule, can carry it out more economically than a government department. There are a few exceptions to this rule, but usually only as temporary expedients. Consequently forest officers are not specially trained for executive work in utilization; they are given a sound knowledge of production, including stocktaking, silviculture and working plans, and enough knowledge of utilization to enable them to maintain contacts with the timber industry. There is little doubt however, that forest engineers specially trained in utilization would, if available, have plenty of scope in advising and assisting the industry. This idea has been developed with special reference to West Africa in an article by J. N. Oliphant (1937).

For the training of African subordinates, there are schools of forestry at Busoga in Uganda, and Ibadan in Nigeria, and courses are held in the Gold Coast and elsewhere. The proportion of native to European staff in the forestry department is higher in Nyasaland than in any other colonial territory. The subordinate native staff forms the link between the forest department and the African farmer, and therefore, it is essential to have facilities for training in each territory, so that the guards and rangers can be as far as possible recruited from the tribes with whom they have to deal.

In most territories the whole forestry estate is directly administered by the forest departments. In some, however, native headmen or native administrations are given certain responsibilities over those reserves of which the principal function is to supply timber for building and firewood. Thus in Nyasaland a village forest scheme, constituted by rules under the forest ordinance, has led to the establishment of some 3,000 village forests in charge of local headmen, and the scheme, under adequate supervision by forest and administrative officers, is working well. These village forests are not in charge of, or financed by, the native administrations, but the village headmen to whom the areas are allocated are the sole authority for management and cutting. They usually carry out simple operations such as weeding and thinning, and institute measures for fire protection. No payment for produce from the village forests is demanded by a headman from his own people. In Nigeria several areas of rain forest, amounting to some 4,600 square miles, of value for commercial exploitation, have been handed over to native administrations, notably a large area near Benin. Exploitation is carried out through concessionaires. Careful supervision by the forestry department is of course necessary, and a European forest officer is seconded to the native administration for this purpose.

The delegation of authority for forest reserves to the native administrations is a logical application of the system of indirect rule, but it involves certain administrative difficulties. A system under which forest guards are responsible not to the forest officer but to the native authority depends for its efficacy on a full appreciation by the latter of the aims and methods of forest conservation. In Tanganyika, though experiments in this direction have been

made, it is argued that since the native fears and shuns evergreen forest and takes for granted its destruction for agriculture or grazing and the thoughtless use of fire, the scattered remnants of the once extensive forests might well disappear before indirect methods of control could be made effective. The forest reserves of this territory are so small that their preservation could not safely be left to persons who do not realize their importance. A few months of neglect or a few years of heavy cutting might result in damage that would take decades to repair.

The *Empire Forestry Conferences* held from time to time provide a means of contact between foresters in different territories. Four of these have been held, the last, in South Africa in 1935, having particular reference to forestry in that Dominion. The statements then prepared by the forest authorities in the various British territories give an excellent picture of the present position. Informal meetings of forestry officers on leave have been organized by the Imperial Forestry Institute since 1936. In consequence of a resolution passed by the Conference of 1920, the *Empire Forestry Association* was founded as a voluntary body, with the objects of fostering interest in forestry, providing a centre of communication, and collecting and circulating information. The official organ of the Association, the *Empire Forestry Journal*, appears biannually, and a handbook is also issued. Apart from these conferences it appears that facilities for the exchange of ideas in forestry are less good than in many other subjects, and that some means of co-ordination of work is required, not only between neighbouring territories, but between those of the East and West African groups. It has been suggested that this could be achieved by the appointment of central directors of forestry for the East and West African territories respectively, and an inspector of forests for the whole colonial Empire, who would spend his time touring and act as co-ordinating officer and advisor. The exchange of officers of midway seniority between different territories would also lead to the dissemination of experience, and some general forestry publication for the African colonies, on the lines of the *Indian Forester* or the *Malayan Forester*, would serve useful purposes as a medium for the exchange of views, and dissemination of results.

FRENCH

In the French colonies the forestry department is a branch of the economic service, which includes also agriculture, animal husbandry, and customs. For West Africa the whole forest service is under the direction of M. Aubréville and each component colony has a separate department with technical experts. The organization for marketing timber is also well developed, particularly for the Ivory Coast, which contains the principal areas of commercial forest. The European staff of the forestry service of French West Africa in 1936 comprised sixteen *Inspecteurs* and twenty-five *Conducteurs.*

BELGIAN

In the *Belgian Congo* forest resources have received considerable attention; references to some published works on them are given later. There is a forest advisor for the whole colony, with a staff of inspectors, while the Katanga has its own service under the *Comité Spécial.* Policy up till now has aimed chiefly at the creation of reserves, organized exploitation being less advanced than in the British or French territories. The difficulty of communications and transport of timber from the main forest areas has been responsible for this condition, but development is now taking place in the more accessible areas.

DESTRUCTION AND CONSERVATION OF FORESTS
(British Territories only)

In view of the alarming rate at which forests in some parts of Africa are being demolished, the allocation of large areas as reserves, under either state or native control, has been a prime object in every territory. A broad classification of these reserves according to the methods by which they are administered, is as follows:

(*a*) Forests under the control of forest departments.

- (1) Commercial forests.
- (2) Forests maintained for the provision of timber or firewood for general consumption, or for special industries such as mines, railways, steamers, etc.
- (3) Important protection forests affecting wide areas.

(*b*) Forests under the control of native administrations.

(1) Small forests and plantations maintained for supplying the needs of the local population.

(2) Small protection forests which are only of local importance.

The table below, compiled by the Imperial Forestry Institute mainly from data in statements by the several forestry departments to the British Empire Forestry Conference of 1935, shows the extent of total forest and existing reserves in the British territories. It should be noted that some of the figures are not comparable because the nature of forest land differs from territory to territory. Savannah forest is not included in every case, as indicated by footnotes.

FOREST RESERVES IN BRITISH TERRITORIES
(Figures in square miles)

	Date of Figures	*Area under Forest*	*% forest of total land area*	*Area of Govt. reserves* (1)	*Area of Native reserves*
Union of South Africa	1936	16,647	3·5	3,890	—
Southern Rhodesia	1933	88,809(2)	59·1	88,786	—
Northern Rhodesia	1936	172,000(2)	59·7	455(3)	?
Nyasaland	1935	4,440(2)	11·8	2,623(4)	180
Tanganyika	1936	4,432(5)	1·3	4,019	85(6)
Kenya	1936	5,821(5)(7)	2·6	4,860	371
Uganda	1936	5,000	6·2	1,846	?
Nigeria	1936	219,050(8)	59·5	6,998	11,118
Gold Coast	1933	13,900(5)	15·1	53	2,383
Sierra Leone	1936	1,500(5)(9)	5·5	74	692

(1) Game reserves and national parks are not included.
(2) Mainly savannah forest.
(3) Government reserves 1934.
(4) Government and native reserves 1936.
(5) Excluding savannah forest, thorn bush and cut areas.
(6) Also non-native private forests, 172 square miles.
(7) Total of existing government reserves and forests awaiting reservation.
(8) Mangrove 7,000, rain forest 37,000, mixed deciduous 14,000, savannah 161,050 approx.
(9) Reserved forests only.

It is a general opinion among expert foresters that the areas which have been acquired as reserves are not yet sufficient to assure future prosperity in any African territory, but the degree

of deficiency varies greatly. In the absence of fundamental knowledge regarding the role of forests in conserving water-supplies and soil, referred to above, it has been necessary to adopt arbitrary criteria in determining the areas to be reserved, such as a fixed percentage of the total land area; the separate reserves are carefully selected with regard to their distribution over the whole territory.

The extensive reservation of large blocks of country as conservation forests is always expensive, so that it is desirable that reserved areas should be worked to provide some revenue, provided that (a) there is sufficient demand for timber to warrant exploitation and (b) any working is on a basis of sustained yield, with regeneration and tending of forest keeping pace with cutting. The clear felling and replanting of areas, which is a commonplace of forestry in temperate climates, is rarely adopted in Africa except as a last resort, because in any tropical or sub-tropical forest only a small proportion of the trees are commercially valuable, and on account also of the detrimental effect of tropical sun and rain on a bare forest soil. The eventual ideal would be for nearly all reserved forests to be brought under working plans,[1] so that conservation can go hand in hand with exploitation and regeneration. Working plans belong, however, to a late phase in the evolution of forestry: the immediate needs in Africa are the conservation of the remaining forests and the development of forest uses.

The principal agent in modifying the original forest vegetation of Africa is the native practice of shifting cultivation, which is often aided by fire. Apart from the destruction of valuable forest, this practice has resulted in places in serious erosion and degradation of the soil. This is particularly noticeable in hilly regions such as Nyasaland, where A. J. W. Hornby (1923) has described the results. As the population increases and the available areas of forest decrease, the results will be more and more serious, and yet the forest areas are the only reserves on which agriculture can draw for its expansion in many parts of the continent, and some experts are of the opinion that shifting cultivation in a modified form will always be the mainstay of native agriculture.

[1] 'Working plans' is an expression used in forestry to imply a detailed programme of felling and regeneration, including replanting where necessary.

The agricultural alternatives to shifting cultivation are discussed in Chapter XIII, but there are certain other measures which involve action by forestry rather than agricultural departments. These may be considered here.

In shifting cultivation, soil is reconditioned by the growth of natural vegetation after being used for varying periods in the production of agricultural crops. It seems that in the more sparsely inhabited regions where the natural balance is still maintained the periods of fallow are sufficiently long to allow good development of tree growth from suckers, coppice, and seedlings, and old root stocks are not destroyed to any extent during the intervening periods of cultivation. Where the areas available for native cultivation have been restricted, it is necessary to accelerate the natural regeneration of tree growth by planting. For this purpose the 'taungya' system of plantation, introduced in Burma many years ago, has recently been applied in modified form in parts of Africa, notably in Nigeria. In Kenya another similar system has been developed, whereby natives are put on to clear and farm the soil first, and the forest department plants useful trees on the same ground as soon as it is vacated by the farmer. It is of course essential that land so planted should not be subjected to new cultivation until the trees are ready for market, and natives are not disposed to submit to the necessary restrictions unless they have large areas in which to practise shifting cultivation without let or hindrance.

For this and other reasons the taungya system has its opponents among expert foresters in Africa. They claim that taungya is contrary to all principles of fixed settlement and to planned land utilization which is essential wherever populations are rapidly increasing; and that areas of light population, where the practice of shifting cultivation can be carried on, are usually so far from markets that the establishment of taungya plantations is impossible on economic grounds. In many places virgin forest brought under cultivation is not vacated until the land is reduced practically to a sterile condition. The problem in such areas is one of planting trees in land where grass has replaced forest growth and which is subject to fierce annual firing. It is, therefore, claimed by some experts that plantation on the taungya principle is no remedy for

agricultural ills, though it may be a palliative in some cases by postponing the destruction of the soil, and is a useful and cheap method of artificial regeneration in reserved forests. Clearly its efficacy is dependent largely on local conditions.

For the purpose of planting up areas vacated by shifting cultivators, exotic trees such as *Cassia* and *Dalbergia* are generally favoured. In many situations the indigenous trees could be used, especially species of *Acacia*, which, like other leguminous plants, have the property of fixing free atmospheric nitrogen through the agency of bacteria to produce nitrates in the soil. In parts of the Sudan the gum tree (*Acacia senegal*), which regenerates naturally, and is sometimes planted on vacated farms, is said to be particularly effective in reconditioning exhausted soil in dry country, and is also of great value in the fixation of shifting sand.

In territories bordering on the Sahara region, forest destruction is said to be partly responsible for the rapid encroachment of dry conditions from the north, e.g. in the northern parts of Nigeria, the Gold Coast, and northern Uganda. In such dry areas acacia trees are frequently cut down to provide fodder for camels, a most wasteful practice which should be discouraged wherever possible. H. C. Sampson (1936) has recorded a similar method for keeping cattle alive in parts of East Africa where country which was grazing twenty years ago is now devoid of pasture. The destruction of forest in one area may cause change to drier conditions elsewhere; for example in Nigeria and other territories of the Gulf of Guinea it is probable that the belt of rain forest near the coast has a considerable effect on precipitation in the arid regions farther north. There is a body of opinion, in fact, which maintains that in order to avoid the menace of the advancing Sahara, the forest reserves in the rain-belt near the coast should be enlarged.

There appears to be no general published work on these questions which deals expressly with Africa, but attention may be drawn to the discussion on the use and misuse of land by R. M. Gorrie (1935), in which the place of forestry in relation to the planning of land utilization is admirably defined. The place of forestry in land-planning is also considered at some length by Major F. M. Oliphant (1937) in a report on his tour of the East African territories. So important are the questions of the relation

of forestry to native agriculture, and measures taken to ensure the interests of forest conservation that it is worth discussing the work done in the different territories in detail, with particular reference to the British territories under the control of the Colonial Office.

In *Northern Rhodesia* native systems of agriculture vary considerably, but all are dependent in part on the clearing and cultivation of bush. In the north-west and north-east the natives depend almost entirely on the temporary cultivation of forest land. The ecological survey officers, Trapnell and Clothier (1937), who have correlated native systems of agriculture with forest types, conclude that the extent of a given agricultural system could be defined by the vegetation type or group of types characterizing the region used. The time required for soil and forest recuperation between periods of cultivation is so long that the area of forest available in some of the reserves is inadequate for the population. Colonel Gore Brown has pointed out,[1] for instance, that in Mpika district each household requires about ten acres of land every two years, and the same land cannot be used again for twenty-five years. Therefore the optimum population is one household per 125 acres of suitable forest, but the actual density is far in excess of this. In addition to the inroads of cultivation in the forests, the growing mining industry is beginning to make itself felt, so that reservation of the savannah forest, for which steps have only recently been taken, is urgently needed.

In *Nyasaland* much of the savannah forest has been modified by shifting cultivation and fire, and in places destroyed, with resultant soil erosion. This process has been accelerated to a considerable extent by the traditional mode of cultivation of finger millet (*Eleusine coracana*), which makes extravagant demands on the land, as described by the Conservator of Forests, Mr. Clements (1933). Wood or grass is burnt by natives to heat the soil before planting this crop, which peculiarly responds to partial sterilization. In some regions, where the forests were destroyed long ago, regrowth is cut on a rotation of two to five years for this purpose, and many acres of regrowth are used for burning one acre of garden. Under this system a new garden is required after one or two crops, and soil impoverishment, followed by crusting, desiccation, and erosion, is

[1] Private communication.

common. As population increases, the periods allowed for forest regeneration are becoming shorter, and destruction is proportionately increasing. The allocation of areas for village forests, inaugurated in 1926, has been mentioned (Clements 1935).

Tanganyika has also suffered the loss or modification of large areas of forest through shifting cultivation, and much damage has been wrought by uncontrolled firing. Judging from climatic and soil conditions, considerable areas of evergreen forest must formerly have existed in the mountainous country, on the alluvial plains surrounding the mountains, and over considerable areas of the coastal plain; but these original forests had been seriously damaged long before the coming of the white man, and now the primeval type of virgin forest seems entirely to have disappeared. Dr. E. O. Teale (1929) has described this process for parts of the territory in relation to the geological conditions which prevail.

The territory is still, moreover, badly provided with forest reserves, which represent less than 1·5 per cent of the land area and include nearly all the remnants of evergreen forest. These reserves are mostly situated in mountainous country or around the heads or courses of rivers and streams. Their object is to ensure a permanent water-supply in stream beds, which is the first essential of man's existence in a country like Tanganyika where the dry season averages six months of the year. There are large areas of savannah forests which could be reserved and, with no more elaborate treatment than protection from fire, should play an important part in the economic life of the country, not only as sources of fuel and timber, but also as water and soil conservers, and as nuclei for schemes of soil amelioration. This is stressed by Professor Troup (1936) in his report on forestry in Tanganyika. Unless such reserves are taken up soon, the pressure of population will make their acquisition difficult. Most of the existing reserves are primarily protective and not designed for commercial exploitation.

In addition to the gazetted forest reserves, there are small reserves under the native authorities set aside for timber and fuel for the native inhabitants. These are organized on similar lines to the village forests in Nyasaland. Additional reserves are taken up from time to time as occasion offers, and considerably more would have

been demarcated by now if it were not for the lack of forestry staff. It remains to be seen whether the native authorities will be capable of controlling cutting in order to maintain the permanence of supply in these reserves. On public lands outside forest reserves, administrative officers may prohibit the destruction of trees on the upper slopes of mountains and hills, and on the banks of streams. This important provision is laid down in the forest rules for 1933.

The department has published (Tanganyika 1932) a useful brochure on forest production and conservation of soil and water, outlining the measures to be adopted regarding planting trees, etc. The present situation of the headquarters of the forestry department in Tanganyika at Morogoro has certain disadvantages owing to its distance both from the seat of government and from the areas where forestry work is most important.

In *Kenya*, as in Tanganyika, evergreen forest has been destroyed by shifting cultivation and also by European settlement, and is now reduced to patches in the mountain areas, but Kenya is, perhaps, better placed to-day, since reservation began earlier, in 1901. The relics have been reserved as Crown forests and can no longer be destroyed, but shifting cultivation is allowed under licence locally in the regenerated areas. Most of the Crown forests are situated in the highlands, and only a small portion are contiguous with native lands. Hence supervision is relatively inexpensive. Excisions from forest reserves have been made from time to time, among them that of an area of 13,500 acres allotted to native tribes in settlement of claims upheld by the Carter Land Commission. The remaining forested land, excluding savannah, amounts to only 2 per cent of the total land area.

In the native reserves large tracts have been seriously denuded and it is recognized that re-afforestation must be effected in the worst areas. The native forest areas which have been created are managed by the forest department and not by native authorities as in the territories described above. The department has obtained funds to re-afforest the Machakos reserve, in which no natural forest survives, but difficulty has been experienced in obtaining land for the purpose from the native authority. A similar situation has arisen in the South Kavirondo reserve, where re-afforestation is badly needed.

The replanting methods of the taungya type, described above, have been worked with success in parts of Kikuyu, and are said to be so cheap and effective that it will be possible to deal with any increase in cutting. In other areas, such as Kiambu district, wattles have been introduced and a profitable native industry has grown up. The development of sawmilling by Europeans makes it unnecessary for the department in Kenya to undertake utilization work. The value of imports, however, at present exceeds that of exports in the timber trade.

In Kenya European opinion appreciates the importance of forests and tree-planting. The Kenya Arbor Society was formed in 1934 under the Presidency of Lord Francis Scott, with Major and Mrs. Ward as secretaries. Its objects are to protect existing forests, to encourage tree-planting, to prevent soil erosion and to repair past damage from this cause.

Huge forest areas in *Uganda* have been cleared in the past. Indeed, some experts assert that there is none of the original flora left except in a few small areas, such as part of the Budongo forest, and the vegetation on the high mountains. Even on the slopes of Mounts Ruwenzori and Elgon, the vegetation is being altered and the forest is receding as a result of burning and cultivation. To some extent the annual destruction of forest is offset by planting under the supervision of administrative officers using funds from the native administrations and trained staff seconded from the forestry department. The trees thus planted are mainly exotics such as black wattle, especially on high land, and *Cassia* in the lower areas. Here the aim is less that of conservation than of definite afforestation with a better class of tree. Native forest reserves like those of Nyasaland have not been developed but the creation of communal forests is under consideration. In this, as in other branches of development in Uganda, the preliminaries for comprehensive land planning are started, and here a joint survey of certain areas by agricultural, geological, forestry, and other officers, referred to in other chapters, will doubtless be of the greatest importance.

The needs of the local population are at present met mainly from the savannah forests, but in these the importance of fire protection is not fully appreciated by the natives, who burn the

savannah areas from end to end each year and thus cause much soil erosion. The proportion of reserved forest to land area is low (see table), but the department have the increase of reserves to 2,812 square miles as an immediate object, and hope eventually for 10,000 square miles, being 12·4 per cent of the land area, these figures to include savannah as well as closed forest.

In *Nigeria* shifting cultivation along the northern and eastern borders of the closed forest zone is resulting in a recession of forest at the estimated rate of 1,000 square miles a year. This destruction of closed forest is said to have had serious consequences for the cocoa plantations of the western provinces. Taungya methods of regeneration are meeting with some success, but it is very doubtful whether re-afforestation by this means could ever keep pace with destruction. The system of taungya in Nigeria is as follows: the native cultivator is induced to work through an area of forest in a fixed direction, clearing and cultivating a series of plots. These are as a rule left to regenerate naturally, under the supervision of native foresters, who follow behind the cultivator, cutting out creepers and undergrowth, and leaving only the valuable trees. The forest experimental station at Sapoba near Benin has been a site for experiments in natural regeneration as well as silvicultural research, and results show how natural regeneration, when controlled in this way, can improve the forests to a marked degree.

The forest reserves of the Southern Provinces are devoted primarily to exploitation, while in the north the first object is conservation of water-supplies. H. N. Thompson, one of the most distinguished foresters of West Africa, laid down the principle that the minimum area of permanent forest in Nigeria should be 25 per cent of the total land area, and the department is still aiming at the acquisition of reserves on this scale. The proportions in different provinces would range from 5 per cent to 64 per cent the latter figure applying only to Benin, which is the centre of the valuable timber forests. In certain areas the department's policy is to hand over the reserves to be administered by the native administrations under careful supervision by the forestry department.

A special problem in the extreme north of Nigeria is connected with the alleged encroachment of the Sahara, discussed in Chapter

IV. This danger has been realized by foresters, geologists, and others for many years, and recently has had special attention drawn to it by Professor Stebbing (1935 and 1937), after a tour through the region, and also by two members of the Nigerian forestry department, F. S. Collier and J. Dundas (1937). Proposals for a huge international forest-belt to stem the advancing sands along the southern border of the Sahara, coinciding roughly with the northern boundary of Nigeria, have been widely discussed and the whole question has been the subject of joint consideration by the British and French authorities. Agreement was reached in 1937, with the result that, while the planting of trees may be impracticable, a great belt of savannah will receive protection along the Sahara's southern confines.

The preservation of forests in Northern Nigeria is connected also with the problem of the tsetse fly. The aim of foresters is to avoid the heavy burning of savannah country, whereas burning is one of the methods recognized for the reduction of the fly areas. A solution to this problem has not yet been reached, though tsetse investigations by the medical department are working towards that end (see Chapter X).

The position of the *Gold Coast* in respect of forests, is perhaps more serious than that of any other British territory. The northern border of the evergreen forest is receding, as in Nigeria, while farther south, extensive areas have been cleared for cultivation of cacao, and others to supply the mines, several of which possess more or less unrestricted concessions to cut timber. The area of forest remaining to-day is less than 14,000 square miles. It is estimated that about 290 square miles are destroyed each year, which means that forest will cease to exist in the Gold Coast in less than fifty years, if the present rate of cutting is not checked. These conditions have led to concentration on the conserving aspect of forest reserves, particularly in the southern parts of the territory, where the cacao industry is situated.

Actually 2,436 square miles are already reserved, and it is hoped that this area will be raised in the near future to something like 8,000, being about 30 per cent of the original area of closed forest. If this is done and the present rate of cutting continues, no more timber or forest land for cultivation will be available after twenty-

five years. It is clear that prompt action is required in reducing the rate of cutting, but quite apart from this, it is probable that a much larger area of permanent forest than the 8,000 square miles anticipated would prove a source of wealth to the country in the future.

The peculiar physiographical and meteorological conditions of the Gold Coast lend themselves to a special selection of areas. The object of the department is to develop reserves in such a way that (1) all the principal water-sheds will lie in forest reserves; (2) there will be a belt of permanent forest on the hilly escarpment which forms the north-eastern limit of closed forest and high rainfall, and is the water-shed between the Pra to the south and tributaries of the Volta to the north; (3) there will be a series of shelter belts in the closed forest region, which is also the region of cacao cultivation; these will run parallel with each other at right angles to the direction of the south-west monsoon; (4) small reserves will be made near the townships to supply local timber for building and for firewood. To provide a basis for the selection of areas the Director of Forestry, Mr. Marshall, recommends[1] the establishment of additional meteorological stations in the closed forest region, and also in the area of savannah forest north of the escarpment where rainfall stations are at present very few.

The provision of shelter-belts is especially important in the Gold Coast in the interest of the cacao industry on which so much of that country's prosperity depends. Many cacao plantations have ceased production as a result of forest destruction in the neighbourhood and the ensuing reduction of humidity around the cacao trees. The exact effect of this exposure appears to be a problem of ecology and microclimatology comparable with that of coffee plantations referred to in Chapter IV. For cacao it is coming to be recognized that small 'reticulate' shelter-belts among the plantations and the raising of shade-trees are likely to be of more immediate benefit than larger shelter-belts at wide intervals. A recent article by H. W. Moor (1937) is of interest in relation to this and other problems of forestry in the Gold Coast.

The principle of the shelter-belt in forestry has been developed especially in America, and some of the conclusions reached there,

[1] Private communication.

available in reports such as that on the plains region of the United States by the United States Forest Service (1935), may have important applications in parts of Africa.

Sierra Leone has only about 840 square miles of reserved forest, representing 3 per cent of the total land area. The unreserved virgin forest is being reduced in area every year, and the secondary forest is steadily deteriorating. Areas of regrowth of increasing size are regularly cut and reduced in quality. In the prevailing climate, soil without forest cover is reduced to sheet laterite which is of very poor value for cultivation purposes. Regeneration of cleared land with the use of *Gmelina*, a very quick-growing tree introduced from India for timber purposes, is under trial at the agricultural research station of Njala and in some forest reserves. The system resembles taungya, but the tree in question forms such a dense canopy that other vegetation cannot grow beneath it, with the result that soil wash is serious on sloping land.

In the *Anglo-Egyptian Sudan* the burning of thorn and savannah forests for shifting cultivation presents a difficult problem, particularly since fire damages the gum-tree (*Acacia senegal*), from which large numbers of Arabs obtain their livelihood. The baobab (*Adansonia digitata*), which grows to a circumference of forty feet and over, is invaluable in certain parts of the Central Sudan where it is used for storing water. Some 30,000 of these trees are filled with water and form the basis of village life. Together with its capacity for storing water the baobab provides ideal situations for the breeding of mosquitoes, and for this reason is regularly destroyed in parts of Africa.

FOREST BOTANY, ECOLOGY, AND STOCKTAKING

Active steps are being taken by the Imperial Forestry Institute, in co-operation with local officers, to advance our knowledge of the component species of the forests, which is at present far from complete. This is being done by the preparation of check-lists (Imperial Forestry Institute 1935–7), leading to annotated catalogues and finally to regional forest floras. It is unlikely that the final stage will be reached in any country for some time to come, but considerable progress can be recorded. The first check-list

(1935) is for Uganda, and the authors, in collaboration with members of the forestry department, show that 1,146 indigenous species are represented in that country. The second list (1936) includes all recorded trees from Nyasaland, a third (1937) includes the trees and shrubs recorded as recurring in the Gold Coast. They are engaged in compiling a list for Tanganyika with the collaboration of Mr. Greenway, botanist to the Agricultural Research Station, Amani, and the late Mr. B. D. Burtt of the tsetse investigation department. Another for Nigeria, as yet unpublished, contains 1,240 species and varieties, representing a 50 per cent increase over the first list published in 1914. For Nigeria also, Mr. J. D. Kennedy, silviculturist in the forestry department, has collected a very large number of species, and has published (1936) a useful book on the forest flora of Southern Nigeria, dealing with over 1,000 species, including seventeen new species and one new genus. There is also an older work on the useful trees of Northern Nigeria by Lely (1925). The Uganda forest department has recently (1934) issued a list of the native names of trees and shrubs in Uganda. Publications dealing specifically with timber are described below.

The enormous variety of forest trees is responsible to some extent for the backward state of African forestry. In practice the African forester distinguishes about a hundred first-class trees, while the rest are grouped together as second class, of little economic importance. The check-lists mentioned, which are edited by Dr. Burtt Davy, are planned to contain keys for the easy determination of species in the field and will provide a valuable guide in the making of forest censuses.

In addition to technical treatises, smaller and more popular books are urgently required to dispel misconceptions with regard to forest trees. There is a prevalent idea that only some half-dozen kinds, representing perhaps one in ten thousand of the actual growing trees, are of any use for timber, and that the rest are of no value except for firewood. It is true that some African timbers compare unfavourably with those from northern countries, being either so hard that they are difficult to work, or so soft that they have little strength and durability, but many of the less-favoured kinds have economic uses. The initiative in preparing such hand-

books must rest with individual officers in the departments themselves. In most territories knowledge is sufficiently advanced for the purpose, and one or two handbooks have been produced, for example a revision by Dale (1936) of E. Battiscombe's useful book on the trees of Kenya, and Miss Steedman (1933) on the trees, shrubs, and lianes of Southern Rhodesia. Lane-Poole (1916) is a comparable work on Sierra Leone, and Broun and Massey (1929), give similar information for the Sudan. In each territory much remains to be done in the ecological study of the forest vegetation including the relation of forest growth to soil, and in stocktaking with the object of ascertaining the composition of the forests and bringing them under systematic working. At present there is little reliable information on the amount of timber available in each forest area, and, to obtain this, more fully trained staff and a long time will be necessary. Air survey (see Chapter II) has opened new possibilities recently, R. Bourne (1928 and 1931), and others have stressed its importance in forestry.

Recent advances in ecology, including that of forests, have been summarized in Chapter VI[1] and the following notes refer mainly to stocktaking.

In *South Africa* the determination of all indigenous and introduced forest trees is undertaken by the forest research section in co-operation with the botanists of the division of plant industry, and very few, if any, trees remain unidentified. In stocktaking steady progress is being made by the forest management section. The history of forest research in the Union has been written recently by J. J. Kotze,[2] chief of the forest research section.

For *Southern Rhodesia* a vegetation map has been prepared, distinguishing the main physiognomic types. In *Northern Rhodesia* vegetation maps based on air photographs taken over considerable areas are valuable in forest stocktaking. For *Nyasaland* a general reconnaissance of forest areas is complete, ecological investigation, with soil classification as a basis, is in progress, and simple working plans for village forests are being prepared. In *Tanganyika* the vegetation is better known than in any other part of East Africa

[1] A number of papers on the subject have appeared in the *Empire Forestry Journal* and the *Journal of Ecology*; some of them are listed in the bibliography.

[2] Unpublished memorandum.

as a result of identification of species, general reconnaissance in connection with the land development survey, and ecological investigation by the tsetse department. The enumeration of growing forest stock has been carried out for nearly all the Kilimanjaro forests and those of Minziro, most of the Shume-Magamba forests and part of those on Meru; also for considerable areas of forest on public lands, containing stocks of *Chlorophora* and *Khaya*. In *Kenya* the identification of species in the forests is practically complete, but no wide-scale stocktaking has been done. Working plans are restricted to the forest areas which are being intensively exploited and to the considerable area of plantations. In *Uganda* a working plan has been laid down for the Budongo forest as a result of aerial photographs which have revealed the extent of growing stock. This is one of the few cases in Africa where air survey has been used for this purpose (Uganda 1934, D.R., p. 14).

In *Nigeria* an extensive enumeration survey of forest reserves is nearing completion and this will enable stocktaking to be put in hand over a large area, but at present only a small region is under working plans. A notable study has been made by W. D. MacGregor (1935) of the silviculture of mixed deciduous forests. For the *Gold Coast* important studies were made many years ago by H. N. Thompson (1910), and forest ecology has been placed on a sound basis by T. F. Chipp (1927). The valuable collections by officers of the Gold Coast forestry department, and in particular by C. Vigne, have provided a good working basis for enumerations and stocktaking. The enumeration of trees in selected areas has been begun and 735 square miles are under administration plans. Stocktaking and exploitation are in progress in *Sierra Leone*.

Finally the comparatively small high forests in the Anglo-Egyptian Sudan along the Blue and White Nile were surveyed in 1928 and 1930, and a scheme for re-afforestation along the Blue Nile is being put into operation. The extent of *Acacia senegal* forest in the Sudan has been estimated at some 50,000 square miles.

For the *French territories* there is not much information available in print. In 1932 Aubréville published an account of the forests and the reserves of timber in the Ivory Coast, and in 1936 an illustrated book on the forest flora of that country. The numerous publications by A. Chevalier (notably 1905–13 and 1920) are also of great

value. For the Gabon region of French Equatorial Africa, there is a published account (A. E. F. 1931) of the forests and forest exploration. Professor Stebbing's book (1937) includes a general account of all the forests of West Africa.

In the *Belgian Congo* extensive investigations have been carried out, and valuable matter has been published, notably by Delevoy (1928–9 and 1933), de Wildeman (1920 and 1934), Vermoesen (1923), and Lebrun (1935). Delevoy's ecological studies in the Katanga are especially important for British workers, since the country described is very similar to that of Northern Rhodesia.

THE INTRODUCTION OF EXOTIC TREES

In afforestation there are two primary facts to be held constantly in mind: (1) a considerable proportion of Africa is, for reasons of soil and climate, suited only to tree-growing, and (2) a number of the indigenous timber trees are of little value when compared with trees which thrive in other continents. Accordingly the desirability of converting useless African bush land into useful forest by planting introduced trees where a sale may be found for them, deserves consideration. In Southern and Northern Rhodesia and parts of East Africa, the experimental introduction of fast-growing exotic trees, particularly conifers and eucalyptus, has been an important part of the work of the forest departments. Much information has been accumulated, a summary of which has recently been written by Professor Troup (1932).

In South Africa the reasons for using exotic trees are different. They are briefly: (1) an economic demand for the soft woods of commerce, particularly to make fruit boxes, coupled with a paucity of indigenous forests, and (2) the inability of the indigenous high forest trees to thrive away from their native habitats on the type of land which the division of forestry usually has at its disposal for afforestation.

The introduction of exotics has created its own problems: some trees have proved to be unsuited to the soil and climate of their new environment, others have succumbed to disease caught from indigenous trees, and still others have brought their own diseases which have taken the upper hand in their new environment or

have spread among the indigenous trees. But on the whole introductions have been successful, and exotic trees will probably be spread through man's agency over wide areas, to the exclusion of many indigenous species.

If it is possible to generalize on this subject, it may be suggested that the tendency is to push the planting of exotics too far, with the result that native hardwoods, often of much value, are disappearing from many areas. Exotics are in most cases quick-growing, very useful when a crop has to be raised speedily owing to scarcity of fuel or timber and there is difficulty in raising indigenous species. They are not in general of better commercial value than many of the indigenous species, and in areas where there is no object in producing a quick crop, it would very often be preferable to regenerate the natural bush, and retain the natural balance.

In Nyasaland exhaustive local trials have shown that exotic trees cannot be grown successfully on the poorer soils; they demand soils of agricultural value which cannot usually be spared for forestry. This is also the case with the majority of the more valuable indigenous trees. In view of the dense population of this territory, forestry has to be confined mainly to the less valuable indigenous species. These supply native needs and have a commercial value when situated near markets.

For the conservation of water-supplies and prevention of erosion, the preservation of the natural bush may be more effective than the planting of exotics. A committee of the recent Empire Forestry Conference recommended that this question should be thoroughly investigated on scientific lines. The exotics, being fast-growing, appear to have particularly high transpiration rates, and therefore may suck up soil moisture and soluble salts more quickly than indigenous forms of vegetation. For this reason farmers and others, especially in South Africa, are warned against planting such trees in large numbers near sources of springs, streams, and vleis. It is clear that the success of large afforestation schemes with exotics depends on careful investigation of their effects on water-supplies and soil generally.

It has been suggested from Australia that conifers, particularly *Pinus insignis*, are wasters of rainfall, in that their foliage prevents light showers from reaching the ground, and the absorptive mat

of shed needles below them prevents all but the heaviest and most continuous rain from penetrating to the deep subsoil. Eucalyptus, on the contrary, is said to be highly efficient in both these respects. The question of the intervention of different trees between rainfall and drainage probably depends upon a variety of morphological, physiological, and ecological characters which could be revealed by research.

The influence of tree species on soil type is also of great importance. It is well known that in Europe conifers are associated with podsolic soils, and broad-leaved trees with brown earth and kindred soil. That is to say, in a climate and on a soil on which either grow, it appears that conifers bring about soil deterioration, whereas broad-leaved species, maintaining a high base-status in the surface soil, bring about soil improvement, or at least maintain the *status quo*. The recent concentration on the planting of conifers in Great Britain has been criticized on this account, on grounds which may be found applicable also in Africa. These questions are fundamental to the formulation of forest policy and deserve careful enquiry.

TIMBERS

The early descriptive work on African timbers suffered from the fact that the correct identity of the species of which the woods were described was not always established, hence much of it is unreliable. Systematic descriptions of the anatomical structure of African woods have been in progress at the Imperial Forestry Institute for some years, special care being taken to establish, with the help of botanical specimens, the correct identity of each species dealt with.

Several hundred authentically-named wood specimens have been received by the institute and a new series of publications entitled *Forest Trees and Timbers of the British Empire*, brought out by the institute (1932–5), contains information on the taxonomy and habits of forest trees and anatomical descriptions of their woods. Three of these are now available, dealing respectively with some East African Coniferae and Leguminosae, twenty West African timber trees, and fifteen South African high forest timber trees. A fourth on fifteen Uganda timber trees will appear

during 1938. The Nigerian forest department have produced an account of over sixty species, largely as a result of work by Mr. W. B. G. Mitchell (1931). In addition to these, publications of the Imperial Institute at South Kensington (1928 and 1931) describe some of the African timbers and point out their uses.

The laboratory at Princes Risborough has completed tests on several woods from Uganda, Tanganyika, Kenya, Nigeria, and Rhodesia. The Union has had special research officers engaged for some time on problems of timber seasoning, at the Forest Products Institution at Pretoria, so that the country is practically independent and consults the Imperial Forestry Institute and the Princes Risborough laboratory only in exceptional cases. At the botanical department of the Witwatersrand University also, work has been carried out on the treatment of timbers against decay due to fungus and insect pests.

For export trade, West Africa holds out greater possibilities than other parts of the continent, owing to its accessibility and to the abundance of commercial timbers which that region possesses. There is already a considerable export, which was largely concerned with mahogany until a few years ago, when several other timbers of quite a different type were launched successfully on the European market, for example, Obeche, Iroko[1] and African walnut. The exports are mostly from Nigeria and French West Africa to Europe.

The development of the trade in timbers from Nigeria and the Gold Coast has recently been the subject of special enquiry by Major F. M. Oliphant (1934a), who pointed out that in the past forest officers had not been given sufficient training in the commercial aspects of forestry. As a result of recent modifications in the programme of training, most colonial forest officers are now equipped from this point of view. By acting to some extent as liaison officer between commercial firms and forestry departments, Major F. M. Oliphant hopes to increase the timber trade from British West Africa. Any such increase depends largely on the European market accepting more lumber and also accepting a

[1] Iroko in West Africa is the same as Mvule (*Chlorophora excelsa*) in East Africa. It is probably the best known timber in the continent as a whole, and is everywhere esteemed for its durability and strength.

reduction in the quality of prime logs. It has to be realized that the very large prime logs, on which trade in the past has largely depended, can no longer be produced after the areas of virgin forest have been worked over. The maintenance of supply for the future depends on silvicultural treatment of the forests, which is still in its early infancy.

From East Africa the only timbers exported in any quantity at present are pencil cedar to Europe and mangrove poles from the coast to Arabia and the Persian Gulf. There is a possibility of export trade in yellow-wood (*Podocarpus*), mvule and other timbers to South Africa. Major F. M. Oliphant's recent tour in East Africa on behalf of the Colonial Office may lead to an increase in such trade.

For the Belgian Congo, there is an extensive collection of specimens in the Congo museum at Tervueren, and investigations have been carried out at the museum's laboratory. Delevoy (1928–32) has written an important reference work on the characters and uses of each kind of wood found in the Katanga.

Little is known regarding the local consumption of timber and other forest produce in any part of Africa, and data are required in order to assess the actual value of forests in each territory, and to forecast future demands. For the non-native population fairly accurate data on consumption could be obtained without much difficulty, but to obtain statistics for the natives would be extremely difficult, if not impossible. Apparently the only figures available are those of Zon and Sparhawk (1923), who give the consumption of wood per head of population as ranging from 2 cubic feet per annum in Egypt and the Sudan up to 73·6 in the Rhodesias. These figures, however, refer presumably to prepared timber, whereas native consumption is mainly represented by round timbers and firewood. Every man cuts for himself and consumption depends on the amount available in each locality. In an area of low population where plenty of wood exists, fires are often kept burning in huts all day and all night, but even this consumption is insignificant in relation to the quantity destroyed in shifting cultivation. In some regions, moreover, as in Nyasaland, numbers of trees are felled to collect caterpillars for food. These illustrations indicate the extreme difficulty of obtaining estimates of any reliability.

MINOR FOREST PRODUCTS

In addition to timber there are certain products from natural or planted forests such as tanstuffs, fibres, flosses, gums, resins, rubber, and oil-seeds. Most of these materials are now obtained from plantations rather than from forest sources and are more suitably discussed in connection with agriculture in Chapter XII, but some additional notes are given below.

The only important supply of *tanstuffs* from Africa is obtained from introduced wattles (see Chapter XII, p. 372). Mangroves are abundant on several African shores, and offer possibilities for a minor industry in producing the brown extract known as 'cutch' used for tanning fishing nets and sails to increase their durability in salt water. The cutch industry is centred in the East Indies. There is, however, an export trade in mangrove bark from Tanganyika, where up to 9,000 tons have been exported in one year. In Nigeria research is being carried out on mangrove extract, but trade has not yet been started.

There is no important export of *vegetable dyes* from Africa, although certain kinds are in local use. There is quite a large dyeing industry in West Africa, with centres at Abeokuta in Nigeria and elsewhere. Indigo, obtained from wild and cultivated plants, is used to dye imported cotton cloths which are worn by both men and women. Steps are being taken to prevent the import of aniline substitutes which threaten the industry and are said to produce dyed cloths of inferior quality.

Many trees and forest climbers yield rough cordage *fibres*, but as a rule these cannot compete with fibres grown as agricultural crops. *Raffia* is a tough fibre obtained from the young unopened leaves of the raffia palm of which several species occur in moist evergreen and swamp forests, *Raphia vinifera* and *Raphia gaertnerii* in West Africa and *Raphia monbuttorum* in East tropical Africa. *Coir*, prepared from the fibrous husk of the coconut, is used for making mats and rough ropes, but is a plantation rather than a forest product. *Floss*, or silk-cotton, is the silky or cottony down surrounding the seeds of certain trees, notably the cotton-trees (*Bombax* spp.), which are widely distributed in the tropics. The fibre is too weak to spin, but is used for upholstery and stuffing

cushions. The seeds contain 28 per cent of oil, and cattle-cake can be made from the residue. The best floss, known as *kapok*, is yielded by *Ceiba pentandra*, which grows wild in Africa, especially near the West Coast. This product is receiving attention in Central Nyasaland and the Tanga Province of Tanganyika, and trials have been carried out in Kenya.

Gum is a viscous substance which exudes from cracks or wounds on the bark of many trees. *Gum arabic*, the most valuable kind, is completely soluble in water and is used as mucilage. It is the subject of a book by Blunt (1926). A considerable part of the world's supply is obtained from the Sudan, where it is the most important article of trade after cotton, and exports have had an annual value in recent years of about £750,000. It is obtained from a number of trees of which *Acacia senegal* (*verek*), the most important, grows abundantly in the dry Kordofan Province of the Sudan and extends westward to parts of Northern Nigeria. As a result of the organization of the gum arabic trade in Nigeria by the forestry department, the export rose from 285,548 lb. in 1930 to 1,431,915 lb. in 1933. Gum-bearing trees are common in other dry parts of Africa, and there is promise of a considerable industry in Tanganyika where the gum arabic has been the subject of an inquiry and report by D. W. Malcolm (1936). There appears to be room for co-operation in marketing between the Sudan, Tanganyika, and Nigeria.

Resins are distinguished from gums by being insoluble in water, but soluble in either alcohol or oil of turpentine. The kinds used for making varnish are collected in the form of copals exuded from trees. There is a considerable export of copals from West Africa, where they are obtained from *Copaifera*, *Trachylobium*, and *Daniellia* spp. The best quality comes from the Belgian Congo, medium quality from the Gold Coast and Sierra Leone, and the poorest from Nigeria. Mertens (1933) has given a full account of recent researches on the constitution of copal from the Belgian Congo, with special reference to its uses. In East Africa the chief copal tree is *Trachylobium hornemannianum*. Copal of fossil origin, known as 'Zanzibar animé', is found near the East Coast, chiefly in Tanganyika, but exports are steadily decreasing.

Most commercial *oil-seeds* are now cultivated as field crops.

Supplies from wild sources are usually of local importance only, unless they possess some special quality or exist in such abundance as to enable them to compete commercially.

The *Oil Palm* (*Elaeis guineensis*) is indigenous to West Africa and until recently has been the sole source of palm-oil, which is derived from the pericarps of the fruits of the palm, and palm-kernel-oil from the kernels of hard-shelled nuts. The oils are used for making soap, candles, and margarine. Plantation cultivation of the oil-palm, however, is increasing and will therefore be more fully considered with other crop plants in Chapter XII.

The *Shea nut* tree (*Butyrospermum parkii*) grows in rather dry country and is a native of West Africa. This too is now being developed as a plantation crop.

The most important indigenous *rubber* tree of Africa is the West African or Lagos rubber (*Funtumia elastica*), a tall tree of the evergreen forests from Uganda westwards to the coast. There are also various rubber vines (*Landolphia* species), the collection of rubber from which was once remunerative. At one time the collection of wild rubber from the African forests was an important industry, but under present-day conditions no species of rubber tree can compete with the Para rubber (*Hevea brasiliensis*) grown extensively in plantations in Malaya and other countries of the Near East, and to some extent in tropical Africa (see Chapter XII).

The Kola tree (*Cola acuminata*) grows wild in West Africa, but most of the nuts, which are eaten as a stimulant, are obtained from planted trees (see Chapter XII). Another nut of commercial value is that of the Dom palm (*Hyphaene thebaica*) which is composed of a form of vegetable ivory used for button-making. These nuts provide quite an important export of the Sudan.

Among potential sources of supply of raw materials for *paper pulp* may be mentioned the East African bamboo (*Arundinaria alpina*) and certain tall savannah grasses, such as the elephant grass of Uganda (*Pennisetum purpureum*), and papyrus. Good paper has been made experimentally from these sources, but economic difficulties have yet to be overcome, because the expense of using celluloine material for this purpose is very heavy. In South Africa attempts are being made at present to use thinnings from plantations of *Pinus patula* for paper pulp, and the utilization of some of

the fast-growing softwood trees of tropical Africa may yet become a possibility, but so far has not yet reached even the experimental stage.

Since hive bees produce very little wax, commercial *beeswax* is mainly collected from wild sources. Of these East Africa is the chief source for the British Empire, and a certain amount also is exported from Egypt and the Sudan. Wild honey is collected by natives throughout the African forests and in many places is an important constituent of native diet. The collection of honey and other products is a contributory cause of the degradation of savannah forests, since it is accompanied by extensive annual firing carried out so that native collectors can move easily through areas which are covered annually by tall grass. There can be little doubt that the damage by regular and thorough burning must in the long run outweigh by far the temporary economic advantages derived from these products.

Medicinal Drugs (see also Chapter VI, p. 166) from trees and vegetation have not yet been found to be of great importance in Africa, though research might affect this position. A few medicinal products, such as *Strophanthus* seeds from Nyasaland, are regularly exported. Many trees and shrubs are used by natives for medicinal purposes, and the products of others appear to make good certain diet deficiencies, for instance, the leaves of the baobab, which are rich in vitamins (see Chapter XVII, p. 574). To produce local supplies of well-known drugs, some tree species have been introduced to Africa, notably *Cinchona*, plantations of which have been established in several places (see Chapter XII, p. 374). More recently *Hydnocarpus* has been introduced from India to Uganda and elsewhere, in the hope of producing local supplies of chaulmoogra oil for the treatment of leprosy.

PESTS AND DISEASES OF FORESTS

An analysis of recent literature shows that little study has yet been made of pests of purely forest importance. It is significant, however, that the dangers of pests and diseases is greatest in plantations of exotic trees, and also in plantations of some indigenous trees, such as Iroko (*Chlorophora excelsa*), made under artifi-

cial conditions differing widely from the ecological environment in which such trees grow in the wild state.

Most of the published work on forest entomology comes from South Africa and deals with wood-borers, the eucalyptus snout-beetle, and insects affecting *Pinus insignis*. The presence of an entomologist occupied entirely with forest problems, on the staff of the division of plant industry in the Union, is of note; his fine work on the eucalyptus snout-beetle, which has led to the control of this pest, is one of the few successful applications of the principle of biological control in Africa (see Chapter X, p. 290). *Pinus insignis* has proved to be very susceptible to disease in parts of South Africa, though not in the large winter rainfall area of the Western Cape Province, where this tree is very much at home. Its diseases have been studied in the botanical department of the Witwatersrand University. The botanical department at Stellenbosch University also studies diseases of trees in collaboration with the pathological section of the division of plant industry.

As a special entomological problem, the gall-fly (*Phytolyma lata*) of *Chlorophora excelsa*, an important timber tree of Uganda and West Africa, has for some years been regarded as a serious pest, the investigation of which is by no means yet complete.

CHAPTER VIII

ZOOLOGY

INTRODUCTION

Zoology in the wide sense bears the same relationship to animal husbandry and fisheries as botany does to arable farming and forestry. That branch of the subject which relates to fisheries is, however, reserved for the next chapter, and insects are considered in Chapter X. Furthermore, the nutrition, breeding and diseases of domestic animals are studied in Africa, not by zoologists in the usual sense but by veterinarians or experts in animal husbandry, whose work is considered in subsequent chapters, so the only branch of the subject which remains for consideration here is that part of the wild fauna which lives on land, and birds.

This fauna consists of the mammals, reptiles, birds, and the multitudes of lesser forms of life such as worms and snails. Africa is unique in the variety of its mammals, many of them of great bulk: some are important to man as sources of food, others as destroyers of man, his stock, or his crops, and many are concerned in the spread of disease. Some reptiles are of direct value for skins or even food, others, such as crocodiles and snakes, because they are predators. Many birds must also be placed on the list of man's enemies on account of the damage they do to crops, to fish supplies, and even to young domestic animals; others provide him with food, sport, and ornaments, or destroy insect pests.

The numerous smaller forms of life are not sufficiently important in human affairs to warrant special mention, but it must be remembered that earthworms are among the principal agents in agriculture, and that land-snails are used for food in many parts. There are regions in Africa where snailing rights play a part in systems of land tenure. But apart from the significance of particular species

to mankind, we have to remember that every individual animal and plant has its place in the highly complicated balance of nature which can be upset all too easily. All knowledge of the flora and fauna is relevant to the problem of maintaining this balance amid the changes introduced by the spread of European civilization.

The subject of wild-life conservation and control is one which is bound to come more and more into prominence as African civilization progresses, not only for sentimental and scientific reasons, but because the natural appeal of wild animals can be turned to pronounced economic and educational account, as such bodies as the Zoological Society of London and the National Parks in America and South Africa have made abundantly clear. This aspect of conservation, particularly in regard to the larger mammals, is becoming widely appreciated in Africa, but it involves particular economic problems, since in many regions climatic conditions make it unlikely that national parks could be developed on a revenue-producing basis like those of Canada and the United States.

The destruction of game animals in the past provided considerable income through the sale of shooting-licences, and still does so to a less degree. Revenue from such products as ivory, rhinoceros horn and hides is diminishing, partly because the animals themselves are becoming scarce, but also as a result of legislation preventing the sale and controlling the export of many animal trophies. Kenya was the first to adopt this system, which is now in force in most other British territories. But these sources of revenue, from the sale of shooting-licences and trophies, are small compared with those which might be expected by attracting numbers of visitors to see and photograph large animals in a comparatively tame state.

It is noteworthy that, while products from wild mammals are being reduced, the economic exploitation of the lower orders is increasing. For example, reptile skins, especially those of crocodiles, snakes, and lizards, have formed the subject of a recent inquiry and report by the Imperial Institute (1933), which will possibly stimulate trade in these articles. Here again, however, the natural balance has to be remembered: many snakes are important factors in the control of rodents which damage crops,

and there is some evidence that monitor lizards consume crocodile eggs and rodents, so the unrestricted slaughter of reptiles would probably have unfortunate results.

Game is at present unpopular with most government departments, settlers, and natives alike, though this attitude is tempered with a sentimental feeling. Settlers and agricultural officers dislike game because it eats crops, natives for the same reason and because the large carnivora sometimes eat both them and their stock, veterinary officers and tsetse workers because game carries disease and competes for pasture. It is possible, however, to find arguments of various kinds for its preservation. There are large areas, for instance, where wild animals provide the only meat available for native consumption, and there are arid regions which are never likely to be of value for agriculture, but which may always support wild mammals, if placed under proper management. In addition there is the argument, which has already been mentioned, for their preservation as a national asset.

Conservation and control are the special objects of the game departments which, though sometimes regarded as luxury departments, in general more than pay for themselves in the sale of licences and the recovery of ivory, either illicit or found in the bush, or obtained from elephants shot in controlling the number and distribution of herds for the purposes of protecting crops. In some territories, for example Northern Rhodesia, where a game department was only established in 1937, following on a survey of the fauna, the commercialization of game has not been on a scale to ensure that a department could be financially self-supporting. This raises the question whether commercialization is a condition precedent to the formation of game departments or whether game departments are necessary preliminaries to satisfactory control of commercial exploitation. Experience in other East African territories indicates that special departments are necessary in the interests both of those who wish to enjoy the wild fauna by sport or study and those who need protection from its ravages. Without such organization, commercial exploitation may not only proceed in directions which are harmful to those interests, but sources of potential revenue are wasted. The revenue-earning capacity of game departments has led to the suggestion that policy in certain

territories, especially with regard to elephants, has emphasized control at the expense of conservation, but such criticism appears to result largely from a misunderstanding of local conditions. It is true that in most areas the general damage by grain-eating birds and rodents throughout the year far surpasses that by elephants, but one night's local depredation by elephants may destroy a year's labour for a few families and reduce them to a state of starvation. It is for this reason that game departments are tending more and more to be occupied with the protection of cultivators when necessary by direct control measures.

A noteworthy example of a controversy which can only be settled on the basis of further research, is that arising from the wholesale destruction of game in Southern Rhodesia as a measure against cattle trypanosomiasis. This provoked protests from scientific workers in Great Britain and elsewhere, who have pointed out that not enough is yet known about the relations between game animals and stock diseases to warrant organized slaughter; that tsetse flies are known to feed on the numerous small mammals, some species even on reptiles such as crocodiles and lizards, so that even the complete extermination of large game animals would not destroy the sources of disease. On the other hand, arguments can be found to support the policy of game destruction. According to Sir David Bruce, for instance, when the cattle in South Africa were destroyed by rinderpest, the tsetse fly and the consequent nagana fever also disappeared; when the cattle were re-established, tsetse fly returned. It is claimed moreover, by R. W. Jack (1934 and 1935) Government Entomologist in Southern Rhodesia, that the present campaign against game animals in the Sebungwe district is really succeeding in its object of driving back the tsetse fly. The criticism of this policy led to the appointment of an authoritative local committee of inquiry who upheld the policy on the ground that other methods of tsetse control, such as 'late burning' and 'densification of vegetation', which have proved successful in Tanganyika, are impracticable in Southern Rhodesia owing to local conditions.

The whole question of the interrelation of game, stock, and tsetse is far too complicated to be summarized in a few paragraphs; it is one on which further research is required as a basis for the formu-

lation of policy. Several aspects of this question are considered at greater length in Chapter X.

ORGANIZATION

Organizations for zoological work as understood here can be visualized as directed towards two objects, first for scientific work in the accurate identifying of animals, in animal ecology and kindred subjects, and secondly for conserving and controlling game animals and vermin. For the first of these purposes museums and certain universities are the principal centres, and for the second there are game departments or similar organizations in the several territories. These two aspects are considered for all the territories.

BRITISH[1]

In Great Britain, the *British Museum* (*Natural History*) in London, under the direction of Dr. C. Forster Cooper, with Mr. M. A. C. Hinton as Keeper of Zoology, is the principal centre for studies in systematic zoology. Specimens are sent to the museum from all over the world for identification by the numerous specialists, some of whom do a good deal of advisory and other work in addition to pure taxonomy. From time to time expeditions are sent into the field by the museum or are partly financed by it in order to enrich the national collections, and the museum undertakes the publication of many results of research.

The *Zoological Society of London*, under the Presidency of the Earl of Onslow and the Secretaryship of Dr. Julian S. Huxley, has the largest collection in the world of living African animals, and a considerable amount of research is undertaken, particularly concerning parasites, since every death at the London Zoo is followed by a full post-mortem examination. The Transactions and Proceedings of the Society contain many papers on African fauna.

The *Society for the Preservation of the Fauna of the Empire*, under the Presidency of Lord Onslow, does valuable work in stressing the conservation rather than the control of game, and in creating pub-

[1] Sir Henry Miers and S. F. Markham (1932) produced a report on the museums and art galleries of British Africa. This has been valuable in compiling part of this section, but additional information from the territories concerned has been incorporated.

lic feeling against its unnecessary destruction. In particular, the society organized special missions by Major R. W. G. Hingston to the East African colonies in 1930, and by Colonel A. H. W. Haywood to the West African colonies in 1932 to investigate the most suitable methods of ensuring the conservation of the indigenous fauna. Contributions bearing on these questions are published quarterly in the society's journal.

Several of the British Universities have taken some interest in African zoology, and research expeditions arranged under their auspices have visited parts of Africa. At Oxford, there is the Bureau of Animal Population under Mr. Charles Elton, which is one of the few centres in Europe for the study of this branch of animal ecology (see page 226).

South Africa has recently seen the development of museums and universities to such a degree that in some respects it is becoming independent of central institutions in Great Britain in so far as systematic zoology is concerned. It is no longer necessary, for example, to send any vertebrate animal to Europe for identification, since there are specialists in each of the component groups of animals at one or other of the South African museums.

There are four national museums: the South African Museum at Capetown, the Natal Museum at Pietermaritzburg, which is one of the most important as a centre of zoological research and which publishes the well-known *Annals of the Natal Museum*, the Transvaal Museum at Pretoria, which has likewise made important contributions to systematic research, field surveys and applied zoology, and the National Museum at Bloemfontein, which is particularly rich in palæontological material. There are four provincial museums: the Albany Museum at Grahamstown, the McGregor Museum at Kimberley, the Kaffrarian Museum at King William's Town, the Port Elizabeth Museum, and a fifth, the Provincial Museum at East London, was started recently. Of these the Kaffrarian Museum is notable in containing the largest study collection of African mammals in the Union, and Captain Shortridge, the Director, has recently published (1934) an exhaustive book on the mammals of South-West Africa; he is extending his studies to Southern Rhodesia. The McGregor Museum has the best arranged collection of geological and ethnological material,

and is likewise responsible for many scientific publications. Only the two last-named have received special grants from the Union Government for scientific publications. Durban has a Municipal Museum which contains exhibits of considerable educational value, but is not a research institution. The zoological departments of the several universities undertake research in many subjects, and have collections or museums in connection with both research and teaching.

The National Zoological Gardens of South Africa at Pretoria, under Dr. R. Bigalke, have a representative collection of living animals from the Union and elsewhere, and it is hoped to develop the gardens into a centre of research as funds permit. There are a number of national parks and sanctuaries for wild animals, the most important being the Kruger National Park in the Transvaal, which has its own warden, Colonel Stevenson-Hamilton, and staff.

Research at most of the institutions mentioned above has been concerned primarily with taxonomic studies, and the accurate naming of animals. This branch of zoology is now sufficiently well advanced in South Africa for study of the animals in the living state to be of real value. Accordingly, in recent years interest in ecological work has developed. Some of the researches undertaken by agriculturalists, veterinarians, etc., are concerned with animal as well as plant ecology. Dr. R. Bigalke (1934), in making a plea for an organized ecological survey of the Union, points out that from 1911 to 1933 the provinces spent a total of £607,674 in connection with fish and game preservation and the destruction of vermin, and suggests that a biological survey would furnish scientific information which would lead to more efficient use of such funds. The survey would be a unit of the department of agriculture, and would devote consideration to pressing economic problems such as the control of predatory animals, noxious rodents and rabies transmitters, and the relation of wild birds to agriculture. He recommends a staff of not less than six biologists with zoology as their principal subject and botany and geology as subsidiaries.

Southern Rhodesia has two museums, each with good collections of fauna: the Rhodesian Museum at Bulawayo and the Salisbury Museum. At the former the senior curator, Mr. Arnold, is a zoologist who has published many contributions on taxonomics,

based on study of the collections. The wild animals and game are in the charge of the chief forest officer of the department of agriculture, with a game warden.

The *Anglo-Egyptian Sudan* has a small Government Museum of Natural History contained in the Gordon College, with a good collection of Sudan birds. There are also Zoological Gardens at Khartoum. The valuable periodical, *Sudan Notes and Records*, has been published for many years and contains results of zoological study. A well-administered game department has existed for many years.

In the *Colonies, Protectorates, and Mandates* there is not so much need as in botany for systematists to be available in the individual African territories, and indeed this would be quite impossible in view of the wider field to be covered and the specialized nature of the work. Nevertheless, collections of local fauna in African museums are highly desirable, and in a few territories steps have been taken towards this end. Extensive collections of special groups such as insects are sometimes made by members of technical departments, and are available for reference at the laboratories concerned.

The museums are generally organized by natural history societies, some of which also publish scientific journals. Thus, in *Kenya* the excellent Coryndon Memorial Museum at Nairobi has already extensive collections which are mainly the result of perpetual and largely voluntary labours by Dr. van Someren. It owes its origin to the East Africa and Uganda Natural History Society, which was established in 1909, and which publishes an admirable journal. There is also the Stoneham Museum at Kitale, started as a private organization and now managed by a board of trustees. *Uganda* has only a very small museum at Kampala. Results of local studies are published in the *Uganda Journal*, founded in 1933. A large and important collection of insects has been accumulated at the agricultural laboratory, Kampala. *Tanganyika* has no special museum in which fauna is collected, but reference collections are being brought together by the biological workers at Amani (insects and birds) and by the assistant government entomologist at Morogoro (insects and small mammals). *Tanganyika Notes and Records*, published half-yearly, was founded in 1936. At Zanzibar there is

an excellent museum with sections devoted to natural history and biology. In *Northern Rhodesia* there is a small museum at Livingstone, which it is proposed to expand in the near future.

Turning to *West Africa*, there is no single museum with fauna collections, except in Achimota College at Accra, which has a few zoological specimens in addition to the extensive herbarium mentioned in Chapter VI. Material is being accumulated, however, at some of the Government laboratories. The *Nigerian Field*, published quarterly since 1932, contains valuable articles by local students. The Gold Coast has a similar journal and *Sierra Leone Notes and Records* appears quarterly.

The action taken by the British colonial territories with regard to the protection of wild fauna since the London Convention of 1900 has been outlined by C. W. Hobley (1933), from whose account some of the following information is taken.

Game Departments are operating in East Africa in Kenya, Uganda, and Tanganyika. The *Kenya* department was the first to be established, and is now under Captain A. T. A. Ritchie. It includes, in addition, two officers on game preservation, a fish-warden, and several officers on the control of game and vermin. It has, however, been impossible for the existing staff, except to a very limited degree, to make scientific studies of the wild fauna, a task which should fall within the department's province. The post of senior assistant game warden has been vacant for some time, and Captain Ritchie is hoping to fill this, as soon as financial conditions in the colony allow, with an officer with full scientific qualifications, who would spend a part of his time on research into the problems which the future of game in Kenya presents.

The *Uganda* department, under Captain C. R. S. Pitman, is ably conducted and has two European rangers and a considerable African staff, among whose duties elephant control figures prominently. In the warden's report for 1935 it is noted, for instance, that 1,546 elephants were killed by the game department during the year, out of a total elephant mortality estimated from all sources at 2,100. The damage done to native agriculture apparently justifies such wholesale slaughter, and if Pitman's estimate of the total number of elephants in Uganda and of their natural rate of increase are correct, drastic action of this nature will not conflict

with the policy of elephant conservation. Estimated figures for elephant population in various African territories and of their rates of increase are quoted by C. W. Hobley (1934) in an article on elephant control. Thus in Uganda the total population number of elephants was estimated by Captain Pitman to be 18,000. The annual increase is considered to be about 2,160 on the assumption that (1) 60 per cent of the elephants are females, (2) the average life of cows is fifty years, and (3) cows commence breeding at twenty years and continue at one in each three years until death. The mortality of elephants in Uganda, including those shot in control operations, and by sportsmen, and those found dead, was 2,300 in 1936, 2,100 in 1935, and for the ten years to the end of 1934 averaged 1,400 per year (Uganda 1934, *D.R.*, 1935, *D.R.*, 1936, *D.R.*). Thus the mortality, though large, seems to be roughly equal to the estimated increase. In the Uganda department's annual reports illuminating notes on the natural history, distribution, and migration of the larger animals figure prominently. A body of knowledge is being built up, which will serve good purpose in future years. The game warden was recently made responsible also for fisheries.

In *Tanganyika*, the department, under Mr. S. P. Teare, has a European staff of five permanent members. The control of elephants and other raiding game has occupied a considerable part of the department's resources since 1924 as native agriculture has increased. There are numerous game reserves and sanctuaries, a few of which it has been impossible to ward actively. The Serengeti complete reserve, together with the adjoining area, which is a pastoral reserve, carries the most wonderful assemblage of mammals of any area on the globe to-day.

Nyasaland had for a few years a small but efficient department: this was dissolved in 1931 as a measure of economy. The game ordinances are now administered by the District Officers. In *Northern Rhodesia* there was until recently no commercial interest in game such as to warrant the creation of a department. In 1931–2, Captain Pitman, warden in Uganda, was seconded to make a preliminary census of game animals and a general faunistic survey; his large report (1934) puts a mass of useful data on record, and as a result of the survey, Mr. T. Vaughan Jones of the admin-

istrative department has been seconded from 1937 to act as game warden and to start a department.

In the *West African Colonies* the game ordinances are administered by District Officers. In most parts very little game is left, the chief agent which has led to their destruction being indiscriminate slaughter by natives, nearly all of whom possess firearms. In the Gold Coast for instance, elephants, formerly numerous, are now according to Colonel Haywood (1932), reduced to about three hundred. This writer considers that a game warden and staff should be shared between Nigeria and the Gold Coast. The Gold Coast has a large game reserve on the Afram Plains, an area far removed and almost uninhabited, so that supervision of game protection is difficult. Recent proposals by F. S. Collier for Nigeria are referred to later. In *Sierra Leone*, Colonel Haywood suggested that as the game belongs essentially to the forest country, the forestry department could undertake its supervision. It appears that additions to the existing forestry staff would be necessary.

FRENCH

In Paris the *Musée National d'Histoire Naturelle*, with numerous departments under zoological specialists, serves the same purpose for the French colonies as the British Museum (Natural History) does for the British. In accordance with the general French policy in scientific development, of centralizing research experts in France and seconding experts for short-term work in the colonies, the museum in Paris has taken an active part in African questions (see Chapter IX).

A number of game reserves are established in French West and Equatorial Africa, and are in charge of the agriculture and forests branch of the *Service Économique*. Several of the game reserves are also forest reserves. There is no special staff to deal with wild animals or to police the reserves, but it is hoped shortly to establish one in West Africa.

BELGIAN

The *Musée Royal d'Histoire Naturelle* in Brussels is a headquarters of Belgian zoological activity. It is under the directorship of Dr. V. van Straelen, who is also President of the *Parcs Nationaux du*

Congo Belge, and is in the closest touch with zoological developments in the Congo. The *Musée du Congo Belge* at Tervueren near Brussels has very extensive zoological collections and a staff of specialists, under Dr. H. Schouteden, who has himself made notable contributions, especially on the birds of the Congo.

In the *Belgian Congo* itself there is no official game organization apart from that which controls the *Parc National Albert* and the *Parc National de la Kagera*. These two parks are under the supervision of the *Institut des Parcs Nationaux du Congo Belge*, which is ruled by a commission and a direction committee. The commission consists of twenty-four scientists, chosen from Belgium, Great Britain, France, Holland, Italy, Sweden, and the United States. The direction committee in Brussels has eight members under the presidency of Dr. V. van Straelen.

PORTUGUESE

Both Angola and Mozambique have game reserves, but no special staff comparable with the game departments of British colonies.

AMERICAN

In addition to the institutions mentioned above, several of the museums and universities of America include on their staffs zoologists who specialize in the study of African fauna. From time to time, moreover, expeditions have been organized in the United States on a large scale to investigate zoological problems in Africa and to make collections of African fauna for their museums.

The American Committee for International Wild Life Protection, with headquarters at Cambridge, Massachusetts, has been active on the question of conserving wild life in Africa, and has published valuable works on the subject, referred to below.

RESULTS

TAXONOMY

In zoology, as in botany, the accurate naming of animals is essential as a preliminary to all other scientific work. In spite of the vast literature on systematic zoology, the worker in Africa is at

a great disadvantage because there is a serious paucity of general reference works of the kind that can be used for identifying accurately even the common animals of Africa. No good purpose would be served by giving an extensive bibliography on this subject, but some of the most useful works published recently on land animals and birds are noted below.

On *mammals*, Captain G. C. Shortridge (1934) has brought together information for South-West Africa into two volumes which include general biological accounts of each species, in addition to taxonomic descriptions. This appears to be the only area of Africa for which a recent detailed account of the mammalia exists. Dr. Glover Allen, of the Museum of Comparative Zoology in America, is compiling a check-list of all described species of African mammals which will be of great assistance to those making a study of this subject. The recent edition of Rowland Ward's records of big game animals (1935) contains much information, and for the primates a valuable monograph of the African species has been written by Paul Rode (1937).

On the *Reptilia* and *Amphibia* there is no general work incorporating the results of recent research. Among authors on these groups, Mr. H. W. Parker of the British Museum (Natural History) and Dr. A. Loveridge of the Museum of Comparative Zoology, Harvard, have written numerous papers on collections from special areas. Dr. Loveridge was formerly resident in Kenya, working at the Coryndon Memorial Museum, and has recently visited East Africa again for scientific purposes. Important among his recent publications are the series of scientific results of an expedition to rain-forest regions in East Africa (1935–7), and a catalogue of African reptiles and amphibia in the Field Museum of Natural History (1936).

Ornithology occupies a peculiar position. Since birds are comparatively easy to identify and observe, their study is often taken up by amateurs, and popular interest is beginning to result in the publication of local avifaunal works, usually of a good scientific standard. As a rule they are arranged in systematic order, but unlike the floras, they contain a mass of information on general biology. With the multiplication of local studies it is unlikely that any counterpart of the work on the whole bird fauna of Africa by

Reichenow (1900–1905) will be attempted. Ornithological taxonomy has moved rapidly since then, and an invaluable summary of up-to-date nomenclature and distribution has been provided by Sclater (1924–30). Excellent regional studies, published recently, are those of Bates (1930) on birds of West Africa, Belcher (1931) on Nyasaland, and Priest (1933–6) on Southern Rhodesia. Works on a larger scale in course of publication are by Bannerman (1930–6) on tropical West Africa, subsidized by the West African governments, of which four volumes have appeared out of the projected six, and by Chapin (1932) on birds of the Belgian Congo, remarkable for its ecological approach. The serious gap in East African ornithology has been filled by two volumes on the birds of Kenya and Uganda edited by Sclater (1938), based on Sir Frederick Jackson's notes and collections, and there will be a further work by Grant and Mackworth-Praed to cover the whole of East Africa from Abyssinia to the Zambesi. For the Sudan there is at present only a check-list by Bowen (1926). For South Africa a new edition of Stark and Sclater's (1900–1906) work would be valuable. An interesting development, at present in its infancy, is the preparation of elementary books on birds primarily for the use of Africans. Winterbottom in Northern Rhodesia and Fairbairn in Nigeria are the pioneers in this field.

Studies on African ornithology now take an important place in the British and German scientific journals, and one local society, the South African Ornithologists' Union, publishes its own periodical, *The Ostrich*. Important papers on African birds have been appearing in the *Revue Zoologique et Botanique Africaine*, the *Journal of Animal Ecology*, and the *Journal of the Kenya and Uganda Natural History Society*. To the last-named Dr. van Someren has contributed a series of papers on the birds of Kenya. The greater part of the literature on African birds is still confined to taxonomy and geographical distribution, with a few scattered field notes. The study of their food relations, phenology, and complete life-histories, is only now beginning. Notable in this connection are recent investigations by Moreau (1935a and b), who, at Amani, has contributed data on the climatic and botanical factors of the environment, with special reference to the birds.

On the whole, the territories under British administration and

the Belgian Congo are best known ornithologically, and are being most actively explored. Within the British areas knowledge is inevitably uneven; for example, the birds of Kenya and Uganda are better known than those of Tanganyika, where a number of island mountains, of potential interest from the evolutionary point of view, are still largely or completely unknown to zoological science. A series of annual grants has been made by the Trustees of the Godman Exploration Fund, connected with the British Museum (Natural History), to enable the birds of those areas to be studied by Mr. Moreau from the research station at Amani.

ANIMAL ECOLOGY

This is a newly developed branch of zoology of which the possibilities are not yet fully realized. It implies the study of every aspect of the dependence of animals on their environment and on each other. Since all animals are dependent directly or indirectly on plants for food, the study of animal ecology involves corresponding studies of vegetation. Such important problems as those created by the tsetse fly can be solved eventually only by exhaustive ecological studies on the tsetse fly itself (autecology), combined with detailed studies of its environment (synecology), such as the distribution of plants and movements of game, stock, and man. Thus the department of tsetse research in Tanganyika is essentially an ecological department.

Economic problems to which animal ecology is relevant are mentioned in nearly every section of this report: diseases of domestic animals and of man, pests of agriculture and forestry, the conservation and control of game animals and birds, and fisheries. On account of this wide scope it is the ecological method of approach rather than ecology as a specialized subject which is important.

Some of the work of game departments in estimating the population of different animals and in studying their migrations takes the form of ecological survey, and is a branch of study which requires much more intensive work before the place of wild animals in the economy of African territories is sufficiently known. The part played by animals in the spread of disease is especially important, and therefore game research is included in the work of the tsetse department of Tanganyika. Many diseases in addition to

trypanosomiasis are carried by wild animals; as a striking example, the recent outbreak of rabies in East Africa may be cited. Owing to lack of knowledge concerning carriers of the disease, the only course possible was to slaughter all wild carnivora over wide areas.

There is a particular aspect of animal ecology concerned with the size and fluctuation of animal populations. Mr. Charles Elton's work at the Bureau of Animal Population at Oxford has shown the importance of this subject in the control of diseases and pests which are directly or indirectly due to fluctuations in wild animal numbers. Data collected (Elton 1931) show that many animals undergo variation in numbers with a periodicity, usually between three and twelve years, which is more or less constant. In general, a particular species increases in numbers during a succession of favourable years and then there is a comparatively sudden reduction, often due to an epizootic disease. Many diseases of wild animals are transmissible to domestic animals and to man, and sometimes the wild animals, although unaffected themselves, may serve as carriers of disease. Therefore the understanding of animal periodicity may aid the control of epidemics among human beings as well as epizootics among domestic animals. Little enough is yet known of this subject even in Europe or America, while in Africa it has scarcely been touched.

A related problem is the introduction of diseases into regions where they were previously unknown. For instance, rinderpest, which is enzootic in Asia, appeared in Egypt in 1844 and 1865, in Abyssinia in 1890, and by 1900 had spread along the Nile valley through East Africa to the southern part of the continent and also to West Africa. To-day there is a constant fear of its spreading throughout the Union. During the passage of the disease through these areas and subsequently at intervals, herds of wild game, especially buffaloes, became infected, spread the disease among stock and died in large numbers. The occurrence of this disease in epizootic form is probably connected with the fluctuation of game populations, and when these are understood there should be a means of forecasting epizootics. A similar example, though of a disease affecting human beings as well as other mammals, is that of the introduction of plague to South Africa, and its spread through the agency of indigenous rodents. This subject, which has involved

work on the fluctuation in numbers of wild rodents, is discussed in Chapter XVI, p. 536.

Apart from work on South African rodents, there have been no other studies on the periodicity of African animals. Isolated observations, however, suggest that zebra in East Africa suffer periodic outbreaks of lung-worm. Again, epizootics of unknown cause among hippopotami have been recorded from the Congo. In Uganda, also, at the south end of Lake Albert in 1932 and in Lake George in 1933, similar hippopotamus epizootics occurred, which started and ended so suddenly that the cause and actual disease were never discovered. As data slowly accumulate, analyses may show that the principle of cyclic fluctuations in numbers is widely applicable, and other important disease relations between wild animals, stock, and humans will doubtless be found. Clearly it cannot be assumed that cyclic fluctuations of northern and of tropical animals are due to similar causes. In this connection the eleven-year sunspot cycle, which appears to be prominent in tropical regions, as was pointed out in Chapter IV, may influence animal and plant periodicity in Africa. Mr. Elton is at present collecting all data from the African continent bearing on variations in animal numbers with a view to testing this hypothesis. Another of Mr. Elton's activities is to edit the *Journal of Animal Ecology*, in which many papers bearing on the ecology of Africa have been published in recent years.

Animal ecology is of great scientific and economic importance, but at present there is very little provision for it. The whole future of the conservation of game animals in Africa depends on it, so an organization may be envisaged when research officers are attached to the several game departments and all results are correlated at some central institution such as Amani, for this is a branch of study in which correlation over wide areas is a necessity.

CONSERVATION OF WILD ANIMALS

Areas in which wild life is protected may be divided into three grades: (i) *Preserves*, in which wild animals are protected for shooting purposes against all except a strictly limited number of favoured individuals. Present-day ideals favour the enjoyment of animals by

all, so preserves are becoming less popular. (ii) *Reserves*, in which no shooting is allowed, but which afford no particular facilities for the public and consider only the conservation of the animals. Reserves exist in virtue of government proclamations, approved by the Secretary of State in the case of the colonies. During the past fifteen years, all the East African colonies have seen extensions or creations of new reserves which far surpass the excisions from old reserves, but there is no statutory guarantee of their inviolability. The local public generally take a lively interest in game reserves, but they are nevertheless open to attack from many sides, and sooner or later some interest which is not compatible with conservation of game may gain control of the areas. (iii) *National Parks* are established by statute, and thus are legally more secure: public interest in the preservation of national parks is on the whole stronger than in the maintenance of game reserves. The type of legal protection which they enjoy may be illustrated by Articles 2 and 4 of the constitution of the Kruger National Park in the Union of South Africa:

'2. The Governor-General may by Proclamation in the Gazette, constitute any other area of land a national park for the purposes of this Act, provided that no such proclamation shall be issued until Parliament by resolution of both Houses has authorized the constitution of any such area as a national park.

'4. The boundaries of any area constituted a park shall not be altered and no portion of such area shall be capable of alienation except under the authority of an Act of Parliament.'

National parks are usually constituted with two objects in view, namely (1) the preservation in perpetuity of natural beauty and interest, including animals, plants, geology, and scenery, and (2) for the recreation and enjoyment of the public. One or other of these aims may be stressed according to local conditions; thus in America the second object takes precedence to the first in some areas, whereas in Africa the interests of wild fauna are preponderant. Even where a large public takes advantage of a national park for recreation, the fauna and flora can be safeguarded by reserving special areas as breeding sanctuaries with limited access, and other areas as sites for camping and other human activities.

The asset of a local urban public is very desirable for a national

park in order to ensure the necessary goodwill and a revenue from regular visitors. So far in Africa only the Kruger Park has this advantage, but the Parc National Albert expects a much increased revenue from visitors in the near future.

According to recent publications of the American Committee for International Wild Life Protection (1933 and 1935), which contain the most recent data readily available, all Africa including the Mediterranean countries and Madagascar, contains about 149 reserves or national parks. The publications cited contain a classified list of these areas which range from a few thousand acres for the protection of particular species to the 8,600 square miles of the Kruger Park and even larger areas in some of the reserves, though the figures given must inevitably be approximations only. The value of these areas for the scientific study of the reaction of animals to their environment, of enzootic diseases and kindred subjects, is incalculable. At the same time it must be remembered that national parks and game reserves are likely to harbour diseases which are subject to fluctuations and may become epizootic among domestic animals in the surrounding regions, so that caution is necessary in the creation and perpetuation of such areas.

Possible lines of future development have been lucidly discussed by J. S. Huxley (1931) in a chapter on 'Wild Life, Sport, and Sanctuaries', but a few additional notes on recent developments may be given.

The *Kruger National Park*, which has been described by Colonel Stevenson-Hamilton (1929 and 1937), evolved from the Sabi Game Reserve, the first wild-life sanctuary ever declared in the continent (in 1898), and has proved to be an asset of marked value to the Union. At the beginning of the century animals were scarce and wild as a result of many years of unrestricted hunting, but a nucleus of most indigenous forms remained, which rapidly increased in numbers as a result of protection, and spread to areas from which they had been absent for a long time. Now, after nearly thirty years of conservation, the tameness of the animals is amazing; in particular they show no concern at the passing of motor-cars. Roads and rest-houses have been developed to such a pitch, as a result of generous grants from the Union Government, that

even the fastidious traveller can enjoy a motor drive amongst most of the larger game animals, viewing them at a distance of a few yards in safety. The park is open to visitors for the dry six months in each year, May to November. In 1928, when it was first opened, 200 motors and lorries paid the entrance fee of £1 per vehicle, this figure rose to 3,000 in 1930 and to 7,936 in 1936. At present the receipts practically balance the current expenditure.

Public demand for the extension of the system was such that in 1931 the Union Government created the Kalahari Gemsbok National Park for gemsbok (oryx), with an area of 3,000 square miles, and allocated two areas of 11,000 acres in the Cape Province as the Addo Elephant National Park for the preservation of the South African variety of elephant, of which few survive, and another 1,700 acres as the Bontebok National Park to preserve a herd of this rare species. The typical or eastern Cape Hartebeest is another very rare animal, of which only one herd of about fifty remains on a farm in Natal. This was placed under official protection in 1936. The mountain zebra remains to-day only in Ondtshon District of the Cape Province and there are believed to be less than one hundred left. It is hoped that the Union Government will take over the farms which contain the remnant herd, and will proclaim a national reserve there similar to that for the bontebok.

In Zululand, the Umfulosi Reserve of some 60,000 acres, which contains over one hundred specimens of the rare white rhinoceros, deserves special mention. The future of this and the Hluhluwe and Mkuzi Reserves, the former also containing a few white rhino, is uncertain at the present, because they are heavily infested with tsetse flies and are regarded as a danger to neighbouring farms.

The Belgian Congo has also seen a striking development of national parks in recent years. The *Parc National Albert* has an area of more than 400,000 hectares. It is in two sections, including all the famous Birunga volcanoes, and was extended in 1934 and again in 1935 so as to include the Shabirimu Mountains, and the valley of Semliki, and that part of the Ruwenzori range which lies within the Congo boundaries. Shooting and fishing are strictly forbidden. It has been conceived on rather different lines from the Kruger Park, since till recently it has been regarded rather as a section of Africa saved from the incursions of civilization, to be

kept as a place for scientific study, than as an economic asset. This attitude, however, is being modified now that the area is becoming easy of access by road. A comfortable hotel has been erected on the shore of Lake Kivu close to the park boundary, and travellers are realizing the interest of the place. The southern section, with the exception of the gorilla habitat on the Birunga mountains to which access is strictly limited, is comparatively uninteresting bush-covered lava plain with little animal life. In the northern section immediately south of Lake Edward, where antelopes in variety abound, lions are plentiful and hippopotami swarm in the shallow water, only a small rest-camp is maintained by the park authorities.

Since the creation of the park in 1925, much scientific work has been carried out. Excellent topographical surveys have been made under the direction of Lt.-Colonel Hoier. Faunistic surveys are being undertaken by Dr. G. F. de Witte of the Congo Museum at Tervueren and by M. H. Damas of the University of Liège. R. P. Schumacher has completed an ethnographical survey among the pygmy inhabitants, and M. L. Hermans, of the University of Liège, is making a magnetic map of the area. Dr. Schouteden (1932), Director of the Congo Museum, has already published an extensive work on the birds.

The *Parc National de la Kagera* is situated in Ruanda-Urundi, along the Kagera River. It was instituted in November 1934, and includes as total reserve nearly 190,000 hectares and as partial reserve nearly 80,000 hectares. In addition the Uélé Reserve (some 4,000 square miles) and the *Réserve Zoologique et Forestière de la Région des Lacs* in the Katanga have recently been raised to the status of national parks. Such appropriation of large areas naturally involves difficulties when the land is actually in use. Belgian policy is to reserve the entire area for wild life. Except for the pigmies who are allowed to remain in the national parks, the native inhabitants are awarded compensation and given land of equal value elsewhere. Land in European occupation is also expropriated. On the other hand, experience in British colonies indicates that a resident native population is not always inimical to the interests of a national park or game reserve; in certain circumstances it may even prove beneficial.

In 1934, there was created in Brussels an institution called *La Fondation pour favoriser l'Étude scientifique des Parcs Nationaux du Congo Belge.* This scientific foundation has an annual income of about 250,000 francs, and its object is 'to promote all colonial scientific researches, and especially those in the *Parc National Albert*, or in other national parks'. Scientists of all nationalities are welcomed, and to make the possibilities of study more attractive a laboratory is being built, with library and museum attached, on the Ruchuru River in the geographic centre of the park.

In *British East Africa*, the elevation of certain of the existing game reserves to national park status is often urged, but no government has yet been willing to allocate to animals for all time large stretches of territory which might in the future be urgently required for other purposes. Moreover, there are special problems affecting certain areas, such as the grazing rights of the Masai tribe over large tracts of country which are the most suitable for game conservation. The financial aspect of establishing a national park depends upon the revenue which may be expected from tourist traffic. The Kruger Park owes its success to the ever-increasing support of a local white population. Visitors from overseas do not contribute a large proportion because climate restricts the open season to months coinciding with the European summer. In the East African colonies, with their smaller local white population, support must depend largely on overseas tourists, and it is unlikely that they will provide an important source of revenue in the near future. Major Hingston (1930) has proposed a scheme for the creation of nine national parks in East Africa: two in Nyasaland, three in Tanganyika, two in Kenya and two in Uganda. Among these the Serengeti Plains to the south-east of Lake Victoria, with a focus to the east in the wonderful Ngorongoro crater, offer the best opportunities for tourist development on the lines of the Kruger Park.

Access to this region is becoming easier every year, by air and by road from Nairobi or Musoma on Lake Victoria, and some definite policy with regard to its future would seem desirable. Major Hingston (1930) gave full details on the proposed conversion of this area into a national park, and the question was discussed after a paper by him to the Royal Geographical Society

(1931). It has been a subject of debate in East Africa during the past few years.

For the *British West African Colonies* Colonel Haywood (1932) advocates considerable modifications in the existing reserved areas. In Nigeria he proposes to substitute for the existing number of small reserves, all inadequately guarded, a large national park of several thousand square miles in one of three possible areas; Borgu in the north-west, Chafe-Kwiambana in the north, or Muri-Wase near the eastern border, the best game area, but very inaccessible and overrun with tsetse fly. For the Gold Coast he suggests abolishing the existing reserves, because the stock of animals therein has been nearly annihilated by native hunters, and making one or two fairly large national parks or permanent sanctuaries. In Sierra Leone all forest reserves are already game sanctuaries for elephants, and the Government has expressed itself ready to set aside two such areas in the east of the Protectorate as general game reserves. In West Africa there is no control over the use of firearms by natives to kill animals for food, and game has been driven farther and farther back, and reduced in numbers to a point where many species may be incapable of re-establishing themselves. The Kruger experience shows, however, what results protection can achieve, and if sufficiently large areas can be found in West Africa there may yet be time to develop a really excellent and accessible park.

F. S. Collier, a member of the Nigerian forestry service, in an admirable series of articles (1935) on the preservation of fauna in Nigeria, considers the results in that territory of hunting by Africans with firearms, and concludes that it would be in the interests of the inhabitants themselves to introduce effective means of conservation. He proposes the establishment of hunting-forests in which hunting is unrestricted for residents in the neighbourhood, but for which licences are necessary for visiting Africans and Europeans. Adjoining these hunting-areas there should be breeding refuges or sanctuaries which should bear a fixed relation to the area of the hunting-grounds served. It would appear that the desired result could be brought about by declaring certain of the forest reserves as game sanctuaries, under the protection of the existing forestry staff. This would render the creation of extra staff

unnecessary, and would fix the responsibility for policing and inspection.

International Agreement concerning Game Preservation

The general effect of civilization has been to drive wild fauna away from foci of development into inaccessible areas which often lie in the regions of international or interterritorial boundaries. Game reserves are, therefore, sometimes situated along boundaries, as a glance at a map of the game reserves of Africa will show. Such reserves cannot serve their purpose unless they are respected by the people on both sides of the boundary. Legislation to prevent killing for commercial purposes by prohibiting the sale and export of trophies can be made more effective if applied internationally, since nearly every territory in Africa has such extensive boundaries that adequate policing is difficult. Another way of controlling the trade in animal products is by tariff regulations in the country of import; it is noteworthy in this respect that a part of the Vandergrift tariff for the United States (1930) has a special section prohibiting the importation of wild mammals and birds in violation of foreign law.

International agreements for the preservation of game have been sought since 1900. The convention of that year, signed by most European powers who control territories in Africa, dealt with the establishment of game reserves, etc., and proposed a uniform system of game ordinances. This convention, though never ratified, was influential in creating interest in the subject. The Convention of 1933, which resulted from the International Conference in London in October of that year and was signed by all states concerned except Abyssinia, lays down as a principle that it is desirable to establish in all territories, if possible, national parks or strict nature reserves. Next, selected lists of animals and plants are given which require special protection. Article 9 lays down methods of controlling, through customs regulation, the export and import of trophies. In Article 10 certain methods of hunting, in particular by means of motor-cars, aircraft, dazzling lights, and poisons, are considered to be prohibitable. The text of the conference has been published by the Society for the Preservation of the Fauna of the Empire and elsewhere, and reprinted by the

American Committee for International Wild Life Protection (1935) with illustrated notes concerning the species requiring special protection. Those scheduled for complete protection[1] are the Gorilla, Aard Wolf, Fossa, Giant Sable Antelope, Nyala, Mountain Nyala, Okapi, Barbary Stag, Pygmy Hippopotamus, Mountain Zebra, Wild Ass, White Rhinoceros, Northern Hartebeest, Abyssinian Ibex, African Elephant (with tusks less than five kilos weight), Water Chevrotin; three birds, the Whale-headed Stork, Bald-headed Ibis, White-headed Guinea-fowl; and one plant, the *Welwitschia* of Damaraland.

The Convention has been ratified by five powers. Since difficulty was experienced in agreement on some of the articles proposed, a protocol was signed which bound the contracting parties to call another conference, after there has been time to make full inquiries into the possibilities of creating national parks, imposing customs legislation, etc. This took place in May 1938, and a third conference is to be arranged if possible in 1939, after which the whole question of fauna and flora preservation should be much better understood.

[1] The list is given in full although a few of the animals, such as the Barbary stag, do not live in that part of Africa with which this survey is mainly concerned.

CHAPTER IX

FISHERIES

INTRODUCTION

In view of the enormous seaboard of Africa, the extent of its great lakes and rivers, and the exuberance of fish life in tropical waters, remarkably little has been done for the development of fisheries. Fish exist wherever there is water in Africa, except in a few small lakes and high mountain streams in the interior, and provide the principal subsistence of numerous native tribes. But the methods of catching and preserving the fish, though employing local facilities in the most ingenious ways, do not turn the resources to the best advantage.

An analogy may be drawn between primitive fishing methods and shifting cultivation. It is pointed out in Chapter XIII that shifting cultivation, though well suited to the needs of native peoples when the population is sparse, is inadequate and indeed extremely harmful, as soon as the population grows beyond a certain limit. Therefore work is being directed in many places towards the introduction of improved systems of crop rotation, manuring and so forth. In the case of fisheries, however, expensive measures for keeping the waters in production are unnecessary. In order to establish permanent industries the only requirements are surveys to reveal the resources, the introduction of modern methods of catching and curing, and the surveillance of fisheries to ensure that stocks are not reduced to dangerous levels.

Compared with agriculture, fisheries offer relatively cheap opportunities for development, but undue optimism should be avoided. An extensive initial survey of resources is desirable, particularly

in connection with maritime areas, and this is a task requiring expert qualifications. The preservation or treatment of the catch is the essence of success for a fishery of any size in the tropics, and the development of an industry would necessitate experiment, skilled work, and expensive plants. The chief consumer of African fish, however, at any rate in the tropical regions, is the African native, and he is likely to obtain the best, most continuous, and cheapest supplies by the gradual improvement of the existing indigenous trade, rather than by the introduction of large-scale industries organized on modern lines.

Recent demonstrations of the value of fish in the dietary of native peoples give an added reason for the development of existing resources. It has lately been shown that the normal diet of most native tribes is deficient in certain constituents, notably protein, calcium, phosphorus and, to a less extent, iodine.[1] These are precisely the constituents provided by fish, and there is little doubt that, if the fisheries resources which are known to exist were fully utilized and fish were made available over wide areas, the general health of natives would be markedly improved. At present a considerable trade in fish takes place among most of those tribes which have no actual prejudice against fish-eating; and even those which have, such as the Kikuyu, are beginning to disregard the taboo when supplies are available.

Fish are generally marketed among natives in a sun-dried or partly smoked condition, forming an article of trade which is unpleasant to transport, but which goes a long way in flavouring the usual dish of millet or maize meal. Experience in many parts of the world shows that natives do not as a rule like what Europeans consider to be properly cured fish, but even so there is clearly room for improving methods. In large fisheries a form of powdered fish-meal would be the most convenient to market, and its manufacture for native food has been proposed in East and in West Africa. The opinion is usually expressed that it would involve too drastic a change in native food habits to be acceptable, and that the initial

[1] Iodine is certainly supplied to a dietary by sea fish, but not much by freshwater fish. There is reason to suppose that the quantity of iodine in any region is a function of the distance from the sea, and the amount of sea-spray which is mingled with the clouds. Hence the interior of Africa probably contains very little iodine and deficiency may be observable in human beings.

expense of putting down plants for large-scale production would be too heavy. It is worth noting, however, that at least one tribe in Nigeria manufacture and store powdered fish for their own use (see p. 247) and that a trade in fish-meal for native food already exists in French Guinea, where the natives have taken to the new food rapidly.

The development of fisheries presents special economic problems in territories where the provision for marketing of surplus stock is regarded as a primary necessity, since the competition of fish with meat as an article of diet might hamper this policy.

From the scientific point of view development depends on knowledge of the fish themselves, both from the taxonomic and ecological aspects. The stocks of exploitable fish depend on the food supplies available for them, which in general consist of other animals, whether small fish, members of more lowly orders of the animal kingdom, such as shell-fish, or the enormous quantity of minute floating forms of both animals and plants, known collectively as the plankton. These in turn depend on chemical and physical conditions or what may be termed the productive capacity of any water region. Knowledge on all of these subjects is necessary for the scientific exploitation of fisheries. A detailed discussion of all these questions is clearly far outside the scope of this chapter, but a few notes on some recent work in Africa are given in the following pages.

ORGANIZATION AND RESULTS

BRITISH

In *South Africa* the Division of Fisheries under Dr. C. von Bonde, of the Department of Commerce and Industries of the Union Government, conducts a fisheries survey of the whole coast of the Union down to the three hundred fathom line, employing a modern steam research vessel, the R.S. *Africana*, which is used also for part of each year in hydrographic survey for the correction of charts. Dr. von Bonde is also fisheries adviser to the Cape Provincial Administration. In Natal there is a separate Provincial Fisheries Department and a Fisheries Board.

Prior to the establishment of the present division of fisheries,

NATIVE FISHERIES

Above: A river fence with basket traps, built by the Luo of the Kavirondo Gulf, Lake Victoria

Below: The net fishery of the Guinea Coast, near Lagos, Nigeria

much work, largely faunistic and taxonomic in character, was done by Dr. Gilchrist, who for many years conducted a fishery survey under the department of agriculture. In addition to the regular official reports, an excellent series of scientific reports entitled *Marine Investigations in South Africa*, was published from 1900 onwards. A monograph of the marine fishes of South Africa by Dr. K. H. Barnard (1925–7) includes all species known southwards of latitude 15°S., and has provided the basis of recent work; but data on any branch but taxonomy are still so scanty that the regulation of the fishing industry cannot yet be based on a scientific footing, although the protective legislation enacted by the Cape and Natal is valuable in the conservation of supplies.

The organization of the division of fisheries is at present under review by the government, which realizes that centralized control of all marine fisheries is essential. The example of India, where each province has its fisheries departments, has shown the disadvantages of such a system; the separate provinces cannot maintain sufficient staff; there is danger of overlapping and consequent waste of effort, and unless economic results are forthcoming quickly, local support is apt to be withdrawn. A new marine biological laboratory is being constructed in South Africa, which will train personnel for the division, so that it may be unnecessary in future to recruit specialists from overseas. It may be suggested, however, that a few officers from the old-established centres of research elsewhere could make a valuable contribution to fishery research in South Africa.

The results of studies by the division of fisheries are published in annual reports, of which twelve have appeared. On problems of fishery technology there have also been published five investigational reports dealing with such subjects as shark fishing and the canning of the Cape crawfish. Bulletins are also issued from time to time on non-technical aspects of the industry. A full review of the scope of the industry is given in a special report (Union of South Africa 1934).

The fishing-grounds of the Union are rich and extensive. They are situated along the west coast from Walvis Bay to Cape Point and along the south and east coasts as far north as Durban. The Agulhas Bank is a large and rich ground producing a species of

sole, which is the basis of a large commercial fishery. All these grounds, with the exception of those off Natal, are suitable for trawling; while in Natal waters, where the nature of the bottom precludes trawling, line-fishing is practised. Survey work off the South-West African coast has revealed a rich ground of large extent, lying beyond the eighty-fathom line.

Commercial fishing is carried out from the various smaller centres by line-fishing boats, while modern steam trawlers, belonging to three companies, operate from Capetown, Mossel Bay, Port Elizabeth, and East London. Thus there are adequate harbour facilities provided for trawlers, and rail transport of fish to the inland centres is easy. In the past much fish which would be considered valuable in Great Britain has been shovelled overboard dead, and it is possible that some of the grounds have been seriously depleted. The division has recently completed investigations, however, into methods of saving immature fish, and the trawlers are now using a larger mesh in the cod end of the otter trawl, whereby waste is materially reduced.

Fish is smoked, canned, dried, salted, and frozen by modern methods, and locally produced products are largely replacing imports. Smoked and frozen fish have been exported for some time and the markets are steadily growing. The Cape crawfish is also the subject of a considerable industry, and there are sixteen canning factories for it on the west coast. Though hard hit by the imposition of quotas in France, the industry is now exporting canned crawfish to Canada and the United States of America, and has also built up a considerable market for frozen crawfish tails. Rigorous restrictions are imposed on the catching of undersized crawfish and females in berry. There are certain proclaimed sanctuaries wherein crawfishing is totally prohibited. Biological work on the Cape crawfish is undertaken by the division of fisheries, and papers on its natural history, reproduction, etc., have been published by von Bonde (1935 and 1936).

Before the war some detailed studies on the marine fauna of South-West Africa were made by German students, and W. Michaelsen of Hamburg (1914 onwards) started a special series of publications which is still continuing. Papers by many experts are devoted mainly to the taxonomy of invertebrate animals; their scope in-

cludes the whole west coast of Africa from Port Etienne southward, so they will be invaluable to future surveys of the resources of the sea along all the French and British coasts.

East Africa

Except in the case of certain sporting fisheries developed through the introduction of trout and black bass, there is no specialized organization in any British territory other than South Africa for investigating the resources of waters, or for the scientific control of fisheries. The work so far done is the result of a few special investigations organized by governments, and of scientific expeditions carried out in short terms of field work.

Interest was taken by the governments of Kenya and Zanzibar in 1928 as to the fishery possibilities on the East African coast. Dr. C. von Bonde, Director of Fisheries in South Africa, was seconded for a few months' survey in the neighbourhood of Mombasa and Zanzibar, and his reports (1928 and 1929), though devoted principally to the improvement of curing methods, contain also some information about the important fish.

Native fisheries always suffer from being confined to the littoral waters, and it is doubtful whether real expansion can occur until the open-water fishing-grounds are available. In this connection experience in Ceylon is instructive. Here ordinary hydrographic survey, with the study of fish treated as incidental, was the first step; the banks had to be discovered and delimited before it was possible to attempt commercial fishing. The continuation of the survey into the littoral zones has not yet been finished in Ceylon, but the results up to date show the value of studies organized in this order.

The consumption of sea fish by natives is unlikely to extend far inland in East Africa on account of transport difficulties, but the *Great Lakes*, which are within easy reach of vast areas of thickly populated inland territory, and from time immemorial have provided the subsistence of many fishing tribes, offer considerable opportunities for development (plate iii, p. 238).

European methods of fishing were first introduced on Lake Victoria, and since 1905 a considerable fishery for the ngege, or African carp (*Tilapia*) has developed from the introduction of

gill-nets. This fish is restricted to the shallower parts of the lake, and in 1927 the governments concerned, fearing that the ngege was being over-exploited, organized the Fishing Survey of Lake Victoria, under Mr. Michael Graham of the Ministry of Agriculture and Fisheries. The cost was shared between the governments of Kenya, Uganda, and Tanganyika. Some six months were spent on the lake, and the report by Graham (1929) is an exhaustive analysis of the ngege fishery, backed by hydrographic and ecological data, with accounts of the other resources which might repay exploitation. As a striking instance of the lack of scientific knowledge prior to the fishing survey, the ngege of commerce, which had been eaten every day by Europeans in Nairobi since the fishery was started, proved to be a species unknown to science. This work was followed in 1929 by a similar survey of Lakes Albert and Kioga for the Uganda Government by E. B. Worthington, the report on which (1929) stressed the value of a fishery for Albert perch (*Lates*) and for *Citharinus* in Lake Albert, and suggested methods which could be applied with advantage in both lakes. As a result of the Cambridge Expedition of 1930–1, Worthington (1933a) published another economic report on the Uganda fisheries. In addition to the official reports, the scientific results of these expeditions have been published in technical journals, notably the results of the Cambridge Expedition (1933–6) in a series of nineteen papers. One object of these and similar publications has been the identification and classification of the numerous varieties of fish. The classical work on African freshwater fish by G. A. Boulenger (1909–16) is somewhat out of date, so the fish fauna is now treated lake by lake in papers by Dr. C. Tate Regan and Miss Trewavas on the family Cichlidae and by E. B. Worthington and Miss Ricardo on the other families. Lakes Victoria, Rudolf, Baringo, Albert, Kioga, Edward, Tanganyika, Nyasa, Bangweulu and a number of smaller waters have been dealt with in this way,[1] and in 1937 Miss Ricardo extended the investigations by field work on Lake Rukwa, where a commercial fishery has recently been started. The ecology of lakes in the Kenya rift valley has been studied by Miss P. M. Jenkin (1936).

[1] Many of the publications are not referred to here or in the bibliography but full information can be obtained by reference to the Freshwater Biological Association of the British Empire.

As a result of the reports mentioned, the foundation has been laid for the development of lake fisheries in East Africa; but there appear to have been certain misconceptions in regarding them as final statements on the fisheries with which they deal. In reality, by breaking new ground, the principal object of the writers has been to point the way for further work, and to stress the importance of creating a permanent research and administrative organization concerned with East African fisheries. It seems that such a department would be best developed on an interterritorial basis, to include the control and development of fisheries on Lake Victoria and all the surrounding group of lakes in Kenya, Uganda, and Tanganyika, and possibly also the sea fisheries.

At present the freshwater fisheries of East Africa are controlled by various departments, a system which has considerable disadvantages, particularly in view of the common interest of the three territories in the control of the fishery on Lake Victoria. In Kenya the fisheries inspector is responsible to the administrative department. The game department, however, has a special officer in charge of fish, especially trout. In Uganda responsibility for the fisheries has recently been handed over to the game department, and it is noteworthy that Captain Pitman, the game warden, has devoted considerable sections of his recent annual reports to fisheries. Pitman has initiated the work of fish marking in Lake Victoria in the hope of tracing the growth and movements of the important economic species. The time, perhaps in the distant future, may be envisaged when there will be biological stations and aquaria on Lake Victoria and at Mombasa for the thorough study of fishery problems.

Modern trends in native policy point to the development of industry on the basis of existing native fisheries; this involves attention to the improvement of methods of catching, curing, marketing, organization, and the control of fishing-grounds. Meanwhile, however, there appears to be no objection to development on a larger scale in certain areas, leaving the initiative to those who consider the proposition sufficiently attractive to invest the necessary capital. In recent years several European companies have begun to exploit the waters of the larger lakes in Uganda, but so far without much success.

Farther south lie Lake Tanganyika and Lake Nyasa, and a number of smaller lakes which still await study. In Northern Rhodesia some preliminary work on the fisheries was done during the faunal survey referred to in Chapter VIII. The report of the survey by Pitman (1934) contains accounts of the native fishing industry, Chapter VII by Pitman, and an appendix by J. Moffat Thompson. High transport charges have hampered development of the native fishing industry. It is cheaper to rail trucks of dried sea fish from Capetown to the copper mines on the Congo border, than to obtain it from the vast Bangweulu region about one hundred miles distant as the crow flies. It is clear, however, that freshwater fisheries take an important place in the life of natives. The Director of Surveys in Northern Rhodesia, Mr. Fairweather, has stressed that serious depredation has resulted from increased activity of local fishermen, in particular through indiscriminate slaughter of immature fish. All these points suggest the desirability of a full study of the fisheries of Northern Rhodesia.

In Tanganyika, Lake Rukwa presents a special problem, since it is highly productive of fish, and lies within easy reach of the Lupa goldfields; a commercial fishery has been established there to supply the mine workers. Miss Ricardo studied the biological conditions of Lake Rukwa and other waters in that area during 1937, and a report on the fishery prospects is now in preparation. Lake Tanganyika has been subjected to intensive faunistic studies, and arrangements are proceeding for a further scientific study by an expedition under Mr. R. S. A. Beauchamp.

The Anglo-Egyptian Sudan has again considerable possibilities, especially in the marine fisheries of the long Red Sea coastline, but these have not yet been the object of much study. F. E. Kenchington (1934) has studied methods of curing and the development of markets. In this territory, however, the prejudice against eating fish, which is widespread among meat-eating and grain-eating peoples, presents an obstacle to such a policy. Kenchington (1933) has also made a study of the Nile perch (*Lates nilotica*) at Sennar. This fish, the largest of those living in African freshwaters, is widely known to sportsmen, but it is also an important food species in parts of the Nile and in Lakes Albert and Rudolf.

West Africa

In spite of the extensive seaboard of the British West African colonies, and the undoubted value of the fishing-grounds, only one small investigation on scientific lines has been attempted. In 1928 Sir Joseph Byrne, then Governor of Sierra Leone, made arrangements for Mr. James Hornell, formerly Director of Fisheries to the Government of Madras, to report on the Sierra Leone fisheries. The field work lasted two months and the report by Hornell (1928a) concludes that: 1. The marine resources are of immense extent and value. 2. Present methods of fishing are inadequate for the needs of the people. 3. With improved and new methods of fishing and curing a large and profitable export trade could be built up. 4. A fish-oil and fertilizer industry might be founded on the Bonga fishery. 5. Government assistance and supervision are required in various ways. Two attempts have been made to establish a fishery at Freetown—in 1912 a trawler averaged a catch of three tons a day for some months, but lack of organization for the marketing resulted in failure. In 1929 a further venture failed, as the trawler employed was not suitable for operating in the deeper waters. It is clear that fishery surveys of the British waters along the Guinea Coast on a larger scale would be valuable. All along this coast there is a native fishery using lines and nets, but there is no doubt that the resources are not used nearly to capacity. An enlargement of the fishery here could probably be made to provide the dense populations of the coastal belt with valuable protein foods of the kind which are otherwise not available from meat, since the region is unsuitable for cattle owing to the prevalence of tsetse flies.

An inquiry seems desirable not only into the fish resources and better methods of fishing, but especially into facilities for marketing and transport. The fish industry of the Gold Coast and Nigeria presents some curious features. Supplies of marine fish are transported for long distances inland by road; these lines of transport are crossed by freshwater fish captured far to the north in the Niger, Volta, and other rivers, some of which are actually marketed in a dried condition among people living on the coast. Moreover, the greater part of fish consumed in these territories is 'stock fish' imported mainly from Norway. Some reorganization of this industry appears to be desirable, particularly through the

institution of co-operative schemes for the marketing of supplies from the local fishery (plate iii, p. 238).

Dr. F. R. Irvine of Achimota College has published two papers on the fish and fishing industry of the Gold Coast (1930 and 1931). Mr. A. P. Brown, also attached to Achimota, has studied and reported (1937) on the industry at Labadi on the Gold Coast, and Miss Field has submitted a short report on the need for improving methods of curing. An American ichthyologist, Mr. H. W. Fowler (1936), has provided an extensive reference work on the marine fishes and fishlike vertebrates from the west coast of tropical Africa, based on material collected by the American Museum Congo Expedition, 1909–15.

In addition to the experience with trawlers in Sierra Leone, it is worth noting that a company attempted to start a fish industry at Lagos in Nigeria some years ago, using a trawler. Operations were discontinued after a short while, partly because the product was not popular with the native consumers, but such enterprise might now prove more successful. West Africa seems to offer good opportunity for a fish-meal and fish-fertilizer industry, with oil as a by-product.

Freshwater fisheries are of less importance in West than in East Africa. The Niger, Volta, and other rivers, however, are sources of fish for internal trade, and Lake Chad, a considerable part of which borders Nigerian territory, offers extensive resources for future development. In Nigeria the situation has been studied by an administrative officer, Mr. J. B. Welman, on whose information the following notes are based.

It appears that native fishing in the rivers has increased considerably in recent years, and the introduction of European nets in some regions may lead to serious depletions of the stock. There is no room, therefore, for large-scale commercial exploitation, but development should be based on a native fishery, and be preceded by an effective system of control. A taxonomic study of the fish has been made, but no ecological work has been attempted, such as could form a basis for a development policy. There are indications of seasonal movement of fish up and down the rivers, perhaps for purposes of breeding. At present unrestricted fishing leads to the slaughter of immature and breeding fish. In addition to a con-

siderable trade in smoked and dried fish, fresh fish are sent alive to several of the markets, especially to Kano. At least one tribe, the Bedde, living beside the River Yo, make and store powdered fish in sealed pots for their own use and for trade. There is abundant material here for building up well-organized native fisheries, but there is great danger of over-exploitation unless some control is enforced.

Looking to the future of African colonial fisheries, it is clearly impracticable for every colony to support a fishery department. The control of fisheries is not in itself a matter needing expert knowledge, provided that policy is based on studies and expert advice is available. The Colonial Office had until recently an adviser on fisheries who had not, however, the research staff available to make the necessary studies. It would appear, therefore, that the establishment of a bureau and research centre for colonial fisheries, similar to the department in Paris mentioned below, might be considered. Such an establishment for the British territories would have the duty of keeping in touch with all colonial development and would have a few permanent experts ready to be despatched for terms of field work. For sea fisheries a basis for such an organization might be provided by the Marine Biological Association of the United Kingdom, with its laboratory at Plymouth under the direction of Dr. S. W. Kemp, or by the fisheries research branch of the Ministry of Agriculture and Fisheries with its laboratory at Lowestoft. The Freshwater Biological Association of the British Empire, with its laboratory on Windermere under the direction of Dr. E. B. Worthington, is already in touch with many developments in Africa and might be used for a similar organization for the fisheries on the lakes and rivers. The East African group of colonies probably have potential fishery resources large enough to warrant a permanent establishment in Africa itself.

FRENCH

In the French colonies, the scientific study of fisheries is considerably more advanced than in British territory, thanks largely to the enthusiasm of Professor Gruvel, who has a special research and teaching department devoted to the subject at the Museum of Natural History in Paris. Colonial fisheries receive publicity also

through the aquarium below the Colonial Museum. During the last thirty years Professor Gruvel has himself carried out fisheries research along most of the West African coast, especially at Port Etienne and Dakar in French West Africa, the Ivory Coast, Dahomey, parts of the Nigerian coast, Cameroons, Angola, and Capetown, and the list of his published works on the subject is long. An account of the fish industry of the West Coast (1913) and a paper stressing the importance of fishery development (1934) are included in the bibliography. In addition several of Gruvel's students have studied fisheries in French West and Equatorial Africa, notably Dr. T. Monod, who published in 1928 an exhaustive account of the fish industry in the Cameroons, and the late J. Thomas (1925 and 1931), who studied the freshwater fisheries of the Niger and the Chad region. The importance of fish as food for native races is stressed in a paper by Gruvel and Petit (1931).

Port Etienne on the coast of Mauretania is the principal centre of development of fishery on modern lines. Much attention is given to the improvement of curing methods and the value of oil as a by-product. In 1936 a further investigation on a large scale was undertaken into the biology of the coastal and deep waters off Senegal. Professor Belloc, of the Sorbonne, is in charge of the scientific work, and states as a preliminary conclusion that the fishing-grounds in the neighbourhood of Dakar are as rich as those of Port Etienne. A research station has recently been established in the French Cameroons for the development of marine fisheries.

The manufacture of fish-meal as a native food, originally tried with great success in Indo-China, has recently been introduced to French West Africa, where it is made at Conakry and finds a ready sale. The addition of a correct quantity of salt to the fish before curing is the chief process required, but where salt is difficult to obtain a small addition of spice to powdered fish is effective in preserving it from insects, and is highly acceptable to the native consumer.

In Morocco and Madagascar much attention is devoted to the commercial possibilities of freshwater fish. In Morocco, at Gruvel's suggestion, a station has been opened at Azron in the Middle Atlas, for the supply of trout eggs to the whole of the Atlas Mountains. There is also a station for industrial pisciculture in this neighbour-

hood which is beginning to produce results. Carp and salmon have been developed in Madagascar with results which are interesting in view of the problems discussed below, caused by the introduction of new species.

BELGIAN

In the Belgian Congo, with its short seaboard, sea fisheries are of slight importance, but the inland rivers and lakes are a source of food for natives. The fisheries have been described by Goffin (1909) and Wilverth (1911). Most of the river fisheries appear to be still in their primitive condition, but several of the rift valley lakes lying between Belgian and British territory have been exploited in order to provide food for labourers in the mines nearby. On Lake Albert, which is near the Kilomoto gold-mines, there has been a fishery for some twelve years, and motor-boats, nets and other gear have been imported. It is said, however, that overfishing has nearly exhausted those parts of the lake in Belgian territory which are easily accessible. This emphasizes the importance of control. A similar fishery was flourishing at the south end of Lake Edward until it was closed down, when the area became included in the *Parc National Albert.* In connection with the scientific exploration of the *parc*, mentioned in Chapter VIII, H. Damas (1937), has made an extensive hydrobiological investigation of Lakes Kivu, Edward, and Ndalaga. Further work of a similar nature is contemplated for Lake Tanganyika, and this, coupled with studies on freshwater fish of the Congo which are proceeding at the *Musée du Congo Belge* at Tervueren, will provide an invaluable basis for fishery developments. A fact of some interest from the economic point of view is that during the past few years it has been profitable to transport fish caught on the Red Sea coast of the Sudan half across Africa, by rail to Khartoum and thence by road and steamer to Kilomoto, south-west of Lake Albert.

THE INTRODUCTION OF FRESHWATER FISH

The oceans, being all in communication, have acquired a natural balance of life through the ages, with the result that every available habitat is already occupied fully by fish best suited to it,

and northern fish such as herring or cod would stand little chance of survival if loosed in African waters. Many freshwaters, however, are isolated from each other, and since most fish are incapable of being distributed naturally over land, some productive waters have remained practically barren of fish life up to the present day. The introduction of suitable fish to these is therefore important in several ways: new food supplies can be made available; since many good waters are within easy reach of towns, recreation can be afforded to Europeans; the popularity of angling as a rival sport to hunting may have a beneficial effect in the difficult work of game conservation; and the sale of fishing licences is a source of revenue.

In tropical Africa the high mountain streams are almost devoid of fish, and certain lakes and rivers in the lower lying areas are similarly barren. In Kenya, for instance, the indigenous fish, though extremely abundant in the lower reaches of the rivers, are restricted, with very few exceptions, to waters less than 7,000 feet above sea-level. In Lake Naivasha again, at 6,000 feet, there was formerly only a very small fish of no value. The reasons for this peculiar distribution are to be sought in the recent geological history of the continent and in past climatic changes, while ecological factors such as water temperature and food supply also play their part.

To the European in Africa, especially in parts of the Union and in the East African highlands, the lack of fish in the streams very naturally suggested trout for the purposes of food and sport; so many introductions of brown and rainbow trout have been made since the beginning of the century, with the result that some of the best trout fishing in the world is now to be had in Africa, especially in Kenya and Natal. During the last few years trout have been established in many of the rivers in Tanganyika, at suitable altitudes on Mount Ruwenzori in Uganda, in Nyasaland, and elsewhere. Trout have also proved successful in the Union of South Africa, and in the Cape Province there are well-developed trout hatcheries at Pirie, King William's Town, Stellenbosch, and Jonkershock.

The management of trout fisheries in the tropics and South Africa calls for research on a number of problems. When intro-

duced to new water which is seldom fished, trout may breed in large numbers, eat up their food supply and so become small and ill-conditioned. Dr. S. F. Bush (1933) of Natal University College has recently started work on this subject in South Africa, where also the Cape piscatorial society has been active in ascertaining the best conditions for sporting fish. Mr. R. E. Dent in Kenya has collected valuable information which is included in a chapter on trout in a book by S. and E. B. Worthington (1933), where other matters relating to East African freshwater fisheries are discussed at some length. Dent's studies are being carried further by Mr. H. Copley, who is devoting attention to the food supply for trout in Kenya streams.

Since trout need cold water (less than 60° F.) for breeding, they cannot enter into serious competition with the indigenous warm-water fish. The altitude down to which they will thrive varies roughly according to the distance from the equator; in Kenya the lower limit of breeding is about 7,000 feet, in Tanganyika on the Western Usambaras 5,500 feet, and in Nyasaland about 4,500 feet. Where fish are required for distribution at lower altitudes, as in Kenya, an indigenous 'carp' (*Tilapia nigra*) has been used with remarkably good results. The most interesting experiment was made in Lake Naivasha, where this fish was introduced in 1925. In the course of three years it had multiplied in such numbers that a predator fish could be introduced to feed on it, and since there is no suitable indigenous fish, the large-mouthed black bass, a native of America which has been naturalized in parts of Europe, was taken to Lake Naivasha. This species has multiplied in its turn so that the lake, which is within easy reach of the settled parts of Kenya, is much frequented for sport, and adjoining land has risen markedly in value. Lake Naivasha lies in an entirely closed drainage system, separated by ranges of mountains from the major rivers of East Africa, so that there is no risk of the black bass escaping to any other water and causing damage to other fish. The introduction of the same fish to open drainage systems in South Africa and Southern Rhodesia, however, is an experiment which appears to be fraught with considerable danger to indigenous species in the rivers concerned.

Lake Bunyoni in the Kigezi district of Uganda has been the

scene of introductions made in the interest of the native population. Here there were originally only one or two very small fish of no value, and in 1919 a small cat-fish, known locally as nsonzi, was introduced and has given rise to an important native trade. Later, the available food supply was found to be sufficient for the further introduction of two kinds of *Tilapia* to this and the neighbouring lakes of the Kigezi district. On the finding by Captain Pitman that the temperature of certain tributaries of Lake Bunyoni is cool enough for rainbow trout, these also have been introduced and are likely to establish themselves in the lake.

The Nile perch (*Lates niloticus*) is a predator which grows to an enormous size and so might be used to feed on small valueless fish and make them available in larger form. Its introduction from Lake Albert to Lake Victoria has therefore been suggested, but this step could not be taken without great risk to the existing well-established fishery.

The experimental introductions outlined above have been criticized by zoological authorities in England, on the grounds that the results from such interference with the balance of nature are impossible to predict, and that the introduced fish may escape from the original sites and invade other waters to the detriment of the original fauna. The view is taken by these authorities that where introductions are made with the purpose of increasing the food supply or for other urgent economic reasons, it may sometimes be necessary to take the risk of upsetting the natural balance; but these should never be made simply in the interests of sport. The Trustees of the British Museum, in particular, have expressed their opinion that such introductions are rarely defensible and that the introduction of the American black bass was much to be deplored.

Such authoritative opinions emphasize the importance of full control of fish introductions, and of adequate biological surveys of the waters for which the introductions are proposed. In the case of trout there is no reason for alarm in tropical Africa since they are barred from the lower waters by temperature. Experience has shown that in some streams the trout have upset the balance of nature by consuming their own food supply too rapidly, but that eventually a new balance is struck. Black bass are also safe in Lake Naivasha since there is no means of escape, but such a predator,

adapted to life in warm water, might cause serious damage if allowed to spread to the principal drainage basins by such means as the transference of fry to private waters. Control has now been instituted in the principal centres of fish introduction: in Natal there is an Inland Fishery Officer, Mr. Day; in Uganda Captain Pitman, the Game Warden, is responsible for fisheries, and in Kenya, the post of Fish Warden, formerly held by Mr. R. E. Dent, is now occupied by Mr. H. Copley. The value of a central research organization for the colonial territories has been suggested above.

PRESERVATION OF FISH FOR MARKET

The possibility of improving native measures of preserving fish has already been discussed. This section is primarily concerned with the preservation of fish on a large scale for commercial purposes. The researches in progress at the Torry Research Station at Aberdeen, one of the laboratories under the Food Investigation Board of the Department of Scientific and Industrial Research, will doubtless have a bearing on African developments.

When large supplies of food fishes are obtainable close to port, the possibilities of extending the market for fresh fish are clearly worth careful consideration. This field of development might not only extend to the inland centres of population which are accessible by rail transport, but also might include markets overseas. The necessary conditions for such a development are (i) supplies of very fresh fish in suitable quantities at the point of distribution, and (ii) the means for preserving quality unimpaired up to the point of consumption. It is possible that the first of these conditions is fulfilled by the large quantities of soles which are known to be on the grounds close to several South African ports, while the second might be achieved by the process of brine-freezing and cold storage.

In the cold storage of fish for long periods the conclusions from research are that fish must be frozen rapidly when quite fresh, must be stored at a low temperature (less than minus 5°F.) and subsequently must be thawed rapidly. Common salt brine, which does not reach a solid state until its temperature is below minus 5°F., is highly suitable for freezing fish, which will remain palatable and marketable for periods of five, six, or even seven

months. Brine freezing has disadvantages in that certain changes are apparent after thawing (some external colour and bloom are lost, the exposed gills and blood turn brown and the flesh is very slightly impregnated with salt), but it is the most effective method yet known for keeping fish for long periods. Brine freezing involves a series of operations preliminary to cold storage, and a costly plant, which must be close to the fishing-ground. The process has been developed only in recent years, but there are already three factory ships operating from Hull and Grimsby and two land plants in Norway. In time tropical African fish may figure as luxuries on European menus.

In various parts of Africa ordinary cold storage is used in the transport of fresh fish to markets away from the source of supply, but there are as yet few ice factories outside the Union. Most of the railways, however, run cold storage vans for the quick transport of food for European consumption. Nairobi, for instance, receives a daily supply of fresh fish, alternately from Mombasa on the coast and Kisumu on Lake Victoria. To increase such facilities, it would seem that the time has come for the development of cold storage transport by road in many tropical territories.

In South Africa the Fisheries Division is now embarking on research into the question of refrigeration of fish and facilities have been granted for this work at the Low Temperature Research Laboratory of the Department of Agriculture and Forestry. In connection with brine freezing of fish, an interesting experiment has been started recently by the National Trawling and Fishing Company of Capetown. This company has purchased the patent rights for South Africa of the *Société Anonyme de Congélation Industrielle du Poisson*, and also a trawler fitted out for their process. By means of rapid freezing the fish are preserved as they come out of the sea.

The general practice of South African fishermen is to remove the head, guts, and blood before placing the fish on ice. This process is satisfactory for most purposes, as the fishing-grounds are located sufficiently close to the various trawler bases and the use of the new method need not necessarily have revolutionary results. The transportation facilities provided by the South African railways and harbours are quite adequate, and even during the warm sum-

mer months fish preserved by this method are transported over long distances to inland centres with very little loss.

During the last few years the export of frozen crawfish tails to overseas markets has been much increased. The tails are severed from the bodies and are packed in boxes containing about 30lb. each and frozen, and they are exported in the refrigerated chambers. Most of the crawfish caught in South African waters are canned for export, and recently research on canning problems has been conducted with a view to indicating lines of improvement. In the report by von Bonde and Marchand (1936) the whole problem is analysed in detail and certain suggestions and recommendations are made. This report follows on a bulletin prepared by the same authors (1935) on the natural history and utilization of the Cape crawfish.

The salt and smoke curing of fish for consumption at points far removed from ports is a process which is likewise capable of improvement through research and experiment. The influence of climatic conditions both on the raw material and on the subsequent keeping qualities of the finished product is an important subject for study. There is some doubt whether fully cured fish will be popular in the native market, but the European consumers, many of whom are situated far from the source of fish supply, are already interested in well-cured fish. In South Africa, the technology of smoking, drying, and salting fish is also under investigation, and during the last decade locally produced smoked fish has gone far to replace the imported article.

During the fishing survey of Lake Victoria in 1927 experiments were made with a view to producing 'kippers' from the ngege (*Tilapia esculenta*) by salting and smoking. The process, which is described by Graham (1929), gave promising results, but it has not yet been taken up commercially. In most of Africa, the problems of fish preservation are to a large extent localized, and depend on climatic conditions, which vary so enormously from place to place. In the west, for instance, a lightly cured fish, which would remain good almost indefinitely in the intensely dry atmosphere near the Saharan border, would be useless within a few days if transported a few hundred miles south to the humid regions of the Guinea Coast. On the eastern seaboard, however, Natal, with its

subtropical climate, has conditions which resemble those of the east coast farther north, Portuguese East Africa, Tanganyika, and Kenya. It would seem, therefore, that close co-operation between these countries will be of advantage as the expansion of fisheries proceeds.

CHAPTER X

ENTOMOLOGY[1]

INTRODUCTION

The importance of insects for almost every aspect of African development is too obvious to require much comment. In this chapter two of the major insect pests, locusts, and tsetse flies, will be considered first: then such other insects will be considered as are pests of cultivation, of stored products, and carriers of diseases which affect human beings or domestic animals.

Most people are inclined to regard tsetse flies, *Glossina*, as the most important biting insects in Africa, in view of the fact that they render nearly two-thirds of the tropical regions unproductive or uninhabitable. But large areas are subject to persistent attack by other biting insects which keep a large proportion of the population at a low ebb or are responsible for heavy mortality. Of these the most important are malaria mosquitoes, *Anopheles*, and the plague fleas, especially *Xenopsylla*. The problems created by these insects will, however, be more fully considered with medicine. Entomology is linked so closely with other subjects that many of its aspects are necessarily considered elsewhere. The principal references are as follows: Chapter IV, on the relation of eco-climates to insect pests; V, effects of termites on soil; VII, pests of forest trees; VIII, tsetse flies in relation to game; XII, pests of crop plants; XIV, pests of domestic animals; and XVI, insects as vectors of human disease.

Once again it is necessary to stress the importance of taxonomic studies, for practically no advance is possible without a ready

[1] The field of entomological research in Africa is so large and so technical that arrangements were made through Dr. S. A. Neave, of the Imperial Institute of Entomology, for a special memorandum on insect pests, other than locusts and tsetse flies, to be prepared by Mr. S. J. E. Southgate, Assistant at the Institute. This memorandum has been freely used in drafting the later sections of this chapter.

means of naming insects. The importance of the British Museum (Natural History), and similar museums in other countries, as headquarters of taxonomic zoology has already been mentioned, but the enormous variety of insects, of which some 7,500,000 species are already known to science, creates difficulties peculiar to this branch of the study. In Africa the insects of no single area are well known, and indeed it is not known what insects are more or less widely distributed. There is, moreover, except with regard to a few groups of South African insects, such as the moths described by Janse (1932–5), a serious lack of taxonomic monographs of a type suitable for local use, so that research work is liable to constant delays for reference to Europe.

The Imperial Institute of Entomology, in collaboration with the British Museum specialists, is performing an extremely important function in the identification of insects and as a clearing-house for information, but if reference works were available, it would be relieved of much laborious work.

Turning to the major insect pests, there are three principal species of harmful locusts. These are commonly known as the *Desert locust*, mainly in the north and east; the *Migratory*, mainly in the west and east; and the *Red*, in the south-central and south. In addition, some anxiety has been caused by another kind, the *Brown locust* in South Africa. Locusts have probably caused more total loss to Africa than any other factor, animal, vegetable, or mineral, in their sudden and overwhelming incursions. The ravages of locusts are, however, intermittent; when every green thing is eaten, they have to move on, and even where breeding takes place, the insects disappear after a time, persisting only in the few permanent centres of dispersal in a different form and living quite a different kind of life. The war against locusts consists, therefore, of a series of intense but comparatively short battles, after which agricultural activity again springs back into life. The intermittent character of this pest may militate against the progress of research, since interest in this work is naturally less when there is no immediate danger from the insects.

The war against tsetse flies, of which twenty-one kinds are known in Africa, eight being really important, is of an utterly different nature. It is a gruelling continuous fight, during which

the flies may make inroads on inhabited areas along one frontier, while on another they are themselves beaten back by the application of scientific knowledge. The war may occasionally take on calamitous proportions with outbreaks of sleeping sickness, but in general the fly is not responsible, as locusts are, for great loss of ground in the progress of civilization, because land occupied by fly has never been utilized by man. There are, however, exceptions to this generalization. In Southern, and perhaps also in Northern Rhodesia, the fly retreated from wide areas at the time of the big rinderpest epizootic in 1902–3 and subsequently recovered a part of its former ground. Sir David Bruce held that the fly's retreat was a direct result of the destruction of game, but not all authorities now accept his view. In another part of Africa the work of the Tanganyika Tsetse Department has recovered some 1,200 square miles of territory from the fly without any serious game destruction, by means which are outlined below.

The field represented by the rest of entomology is so huge that it is useless to single out instances where progress is held back by insect pests and where it has taken leaps forward as a result of pests successfully controlled. There is one aspect of the question which deserves stressing, however, and that is biological control by parasites or predacious insects. Many people think of insects in general as harmful creatures, but examples are growing in number year by year where pests, whether animal or plant in origin, have been stamped out or put under control by the use of beneficial insects, usually in the form of parasites. Biological control of pests has not found wide application yet in Africa, except in South Africa, where the eucalyptus snout beetle and other pests have been controlled (see later). Many experiments have been made in other parts of the continent, notably in relation to the coffee mealy bug in Kenya, but the application of this method is limited since it is only likely to be successful with introduced pests. Though not usually included under the designation of biological control, plants can often be used with effect in the control of pests; thus dangerous species of mosquitoes can often be controlled by planting trees to shade their breeding places.

Another entomological problem, rather different from those connected with pests of plants or vectors of disease, is that of damage

to buildings by termites. The losses caused by these insects throughout Africa are great, yet little progress has been made in combating their ravages by means of efficient wood preservatives, or by adopting termite-proof methods of construction. The problem is further complicated by the differences of habit among the various species.

ORGANIZATION (*British only*)

The *Imperial Institute of Entomology*, under the direction of Sir Guy Marshall, serves as a clearing-house for information concerning applied entomology throughout the Empire. With its headquarters at the British Museum (Natural History), it is in close touch with the taxonomic entomologists on the museum staff. The *Review of Applied Entomology*, published monthly by the Institute in two sections—A. Agricultural, and B. Medical and Veterinary—contains abstracts of all the important papers in economic entomology published throughout the world. Without the Review it would be quite impossible for entomologists engaged upon these subjects in Africa to keep up to date. The *Bulletin of Entomological Research*, published quarterly by the Institute, is kept for original contributions that bear directly upon the subjects covered by the Review. The Imperial Institute of Entomology, together with the Imperial Mycological Institute at Kew, which formerly were independently organized, in 1933 came into line with the eight Imperial Agricultural Bureaux (*see* Chapter XI). They are now under the control of the Executive Council of the Imperial Agricultural Bureaux, so that co-operation between all the central institutes dealing with Empire agriculture is secured.

Under the general direction of the Institute of Entomology is the laboratory at Farnham Royal, where researches on living insects of economic importance are undertaken, and which supplies insects by the thousand required in the Empire for purposes of biological control.

South Africa has a considerable number of entomologists in the Department of Agriculture and also a special organization for research on locusts, but the colonial territories have only from one to four entomologists in agricultural and veterinary departments,

whose normal duties are to study individual pests. Many of the medical departments also maintain entomologists for special study of such insects as mosquitoes, fleas, lice, and other vectors of disease. A general idea of the equipment of individual British territories for insect work is provided by the following list:

ENTOMOLOGICAL STAFF

<table>
<tr><th>Territory</th><th>Plant Industry</th><th>Animal Industry</th><th>Tsetse research</th></tr>
<tr><td>Union of South Africa</td><td>19</td><td>3</td><td></td></tr>
<tr><td>Swaziland</td><td>1</td><td></td><td></td></tr>
<tr><td>Southern Rhodesia</td><td colspan="2">2</td><td></td></tr>
<tr><td>Northern Rhodesia</td><td colspan="2">1</td><td></td></tr>
<tr><td>Nyasaland</td><td colspan="2">1</td><td></td></tr>
<tr><td>Tanganyika</td><td colspan="2">2</td><td>8</td></tr>
<tr><td>Kenya</td><td>3</td><td>1</td><td></td></tr>
<tr><td>Uganda</td><td colspan="2">4</td><td></td></tr>
<tr><td>Nigeria</td><td>1</td><td></td><td>2</td></tr>
<tr><td>Gold Coast</td><td>1</td><td></td><td></td></tr>
<tr><td>Sierra Leone</td><td>1</td><td></td><td></td></tr>
<tr><td>Anglo-Egyptian Sudan</td><td>8</td><td></td><td></td></tr>
<tr><td>Empire Cotton Growing Corporation</td><td>3</td><td></td><td></td></tr>
</table>

The difficulty which individual territories have in providing an adequate staff of technical research officers has been emphasized in earlier chapters. In connection with forestry it was suggested that great advantage would be derived from the attachment of research officers to the Imperial Institute of Forestry ready to undertake short-term research in Africa. A similar scheme in regard to the Imperial Institute of Entomology might well receive consideration.

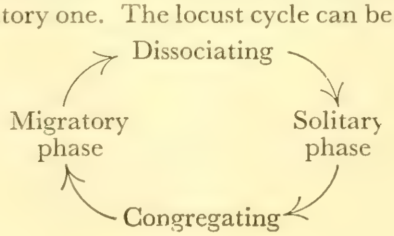
LOCUSTS

One branch of the Imperial Institute of Entomology, developed since the recent overwhelming locust invasions in Africa, is concerned with the international locust organization. A sub-committee on locust control was set up by the Committee of Civil Research in April 1929, to consider the desert locust. This became a committee of the Economic Advisory Council in January 1930, when the Committee of Civil Research was absorbed into that body, and in July 1931, its terms of reference were extended to

cover other tropical African locusts. Scientific knowledge on this subject is due in a large measure to the researches of Mr. B. P. Uvarov, who originally worked out in Russia the basic idea of the 'phase theory'[1] of locusts. In his capacity as a member of the Committee on locust control and as senior assistant in the Imperial Institute of Entomology, Mr. Uvarov has been largely responsible for the valuable reports of the committee. Uvarov has also summarized the position in a short article (1934), so that only an outline need be given here.

International conferences on measures against locusts have taken place in 1931, 1932, 1934, and 1936 (Conference, International Locust, 1934), and it was agreed in 1931 that the Imperial Institute of Entomology should be the international centre for anti-locust research in all Africa. Monthly reports are now sent in from every affected territory except Abyssinia. These are all analysed and plotted at the Institute, with the result that the annual surveys prepared by Uvarov (Economic Advisory Council 1933–7) include a most illuminating series of maps showing the movements and incidence of each species. The accumulation of these data is leading to conclusions concerning the location of the all-important centres of dispersal of the three species. The suspected centres are in sparsely inhabited and inaccessible areas, and in order to locate them exactly and to investigate methods of early control, intensive field investigation by entomologists devoted entirely to the problem on hand is essential. This has been financed from funds contributed half from British colonies and half formerly from the Empire Marketing Board, and later from the Carnegie Corporation, which enabled the following officers to be maintained in the field: Mr. H. B. Johnston and Mr. D. R. Buxton in Uganda and neigh-

[1] Uvarov proved that locusts in general show a fluctuation between two phases, solitary and migratory, the latter appearing at intervals and dying down after a period of intense activity. The solitary locusts live in restricted special environments, and when they become too concentrated change into the migratory phase. Thus the all-important task in locust control is to locate the centres where the solitary phase can change into the migratory one. The locust cycle can be expressed in a diagram:—



bouring territories working on the migratory locust, Mr. R. C. Maxwell-Darling in the Sudan and Arabia on the desert locust, and Mr. A. P. G. Michelmore in Northern Rhodesia and Tanganyika on the red locust. The Union Government have not contributed funds to this central organization, but the Union Department of Agriculture has itself done important work and has contributed to the general scheme by sending an officer, Mr. Lea, to work on the red locust in East Africa during 1935–6. The team of workers mentioned were enabled to study in the field till 1937, when, however, the funds were exhausted, and only one, Michelmore, remained for a year to add to fundamental knowledge of locusts.

It has already been pointed out that interest in the financing of locust research is apt to diminish as the outbreaks abate. But there are strong indications that locusts will prove, like other animals, to have a more or less definite periodicity of population. There is a possibility that the locust cycle comes round about every eleven years, and it may be correlated with the eleven-year cycle of sunspots, temperature, evaporation, and lake levels which has been referred to in Chapter IV. In any case it seems certain that the cycle will come round again, and that as population and cultivated areas increase, the damage done will be progressively more serious in each outbreak. The continuation of research in the intermediate years between the outbreaks is, therefore, of the first importance. Above all, field work should be continued until the central headquarters of the solitary phase of each species are located in detail, and subsequently a constant watch should be kept on them so that swarming can be forecast and perhaps nipped in the bud.

In addition to the locust work centred in the Imperial Institute a number of other independent researches are in progress. In South Africa, Professor J. C. Faure of Pretoria has been appointed Director of Locust Research for the Union. With four entomologists and two assistant entomologists he is engaged in field and laboratory studies on the bionomics of locusts and in collating data from all parts of the Union. In an important work by Faure (1935) the details of the red locust's life history are established. The government entomologists in Nigeria, Mr. Golding, Mr. Lean, and Mr. Gwynn, have made a special study of locusts in the suspected

outbreak centres near Lake Chad and in the French Sudan (Golding 1934 and 1935; Lean 1936).

For the French possessions there is a centralizing committee in Algeria working in close co-operation with the London Institute. The French organized special missions to investigate the French African territories with regard to the migratory and desert locusts. M. Zolotarevsky is in charge and is assisted by another entomologist and a meteorologist, while another government entomologist is under his instructions.

The degree of co-operation in locust research between Nigeria and these French territories is considerable, and while Mr. Lean was permitted to investigate certain areas in the French Sudan, a French mission with M. Zolotarevsky at the head has visited the Chad area together with Mr. Golding.

In the Congo an entomologist, M. Bredu, is at work on the red and migratory locusts, and he has explored several important areas in the Eastern province, as well as in the Katanga. In Mozambique laboratory work on the red locust is progressing at Lourenço Marques, and the Italian Government have throughout shown great interest in the investigations.

The essential preliminary to control measures is a system for forecasting the movements of swarms, but before this can be established the effect of weather on movements must be known. As suggested at the 1934 locust conference in London, many data could be collected by recording locust swarms simultaneously with climatic conditions at all first and second class meteorological stations, and this is now being carried out in some territories, while arrangements have been made with the Meteorological Office for preparation of monthly weather maps for the whole continent of Africa, which can be then directly compared with the maps of locust movements prepared at the Imperial Institute of Entomology.

Parasites of locusts, which could be used for purposes of biological control, have been sought by many workers. The most hopeful so far discovered is a fungus (*Empusa gryllae*). This is known to take heavy toll of swarms in several parts of Africa, but a means of increasing its depredations artificially has not yet been discovered, and the prospects are not very great.

In order to study locusts in the laboratory, consignments of the living insects and their eggs have been brought to this country by air on several occasions. They breed readily in captivity so that detailed experiments on their bionomics are possible. Such have already been made at Pretoria University, by the Imperial Institute of Entomology in the British Museum (Natural History), the Imperial College of Science and Technology, London, and Cambridge and Birmingham Universities. In particular, Professor J. C. Faure, working at Pretoria in 1932, succeeded in changing each species from the solitary into the migratory phase under experimental conditions. If only work such as this could be carried on in laboratories simultaneously with field work at full strength, from now until the next wholesale outbreaks occur, knowledge might be expected to have advanced far enough to have real effect in control when occasion demands.

A recent development, which promises a certain degree of success in the defence of crops, is spraying flying swarms with poison dust from aircraft. Experiments with different poisonous substances for the purpose have been made on living locusts in the Sudan and in England, under the Economic Advisory Council, and the process was tested to some extent during 1934 in Rhodesia on flying swarms with the aid of Imperial Airways craft fitted for the purpose. The Union is experimenting by spraying settled swarms with a more simple apparatus. There are many technical difficulties with regard to air spraying; arsenical powders, for example, are dangerous to stock and to man, and cannot at present be guaranteed not to cake. The present situation with regard to this aspect of locust destruction is that some degree of success has been attained with arsenic, but a technique for its safe use in populated country has not yet been evolved. If a substitute which is non-poisonous to man and beast can be found, dusting from aeroplanes will have great possibilities. In the meantime, baits made of bran, or other similar material, moistened with arsenical solution remain the best method for extermination of locust swarms.

Up to now measures of direct control have seldom proved efficacious, except in highly cultivated areas, and it is somewhat anomalous that the sums of money expended in the wholesale

slaughter of locusts are out of all proportion to the sums spent on research. Such measures can never prove really effective since agricultural country, where locusts can be reached by bands of natives, adjoins much wider areas where the insects can feed and breed at peace. In settled territories extensive control operations have sometimes been organized by governments as a response to public feeling that something ought to be done rather than in a belief in the efficacy of the methods. No more than some measure of defence for standing crops can be expected from these attempts to control widespread invasion.

Therefore, the efforts towards a successful solution of the locust problem are at present concentrated on the discovery of the 'outbreak centres', where the transformation of the harmless solitary locusts into the swarming phase can occur. The results of the international investigations in this respect are most encouraging. Indeed, it has been definitely found that the invasions of the migratory locust can arise only from a single restricted area on the Middle Niger; that the swarms of the red locust originate from two or three areas in Tanganyika and Northern Rhodesia which have been defined; and that the desert locust can transform into the gregarious phase only in certain parts of the Red Sea coasts. In contrast to the relative inaccessibility of the outbreak centres of the above-named species, the brown locust of South Africa breeds permanently in the comparatively well-known region of the Karroo.

The conditions leading to the transformation of phases in the field have also been elucidated to a great extent, so that it appears already possible to embark on the next stage of the problem, viz. the establishment of permanent organizations for the regular supervision of all known and suspected outbreak areas, with a view to suppressing incipient outbreaks as soon as any signs of phase transformation are observed. There is every reason to think that in this way it may be possible to prevent the appearance of the swarming phase and the invasions of wide regions by its swarms. The costs of such permanent preventive organizations are estimated at only a small fraction of the expenditure required to combat swarms when they spread, and they should be regarded as insurance premiums against incalculable losses. The difficulties of

establishing these organizations, which should be financed and controlled internationally, are obviously very great, but failing this, African agriculture will continue to pay heavy periodical tribute to locusts. The matter is urgent, since definite signs of the approach of a new swarming period of the desert locust have been observed on the Red Sea coast of the Sudan during the winters of 1936–7 and 1937–8 and local measures to suppress the incipient outbreak may prove to be insufficient.

TSETSE FLIES

The part of Africa inhabited by tsetse flies includes most of the tropics, and is a belt of country nearly 2,000 miles wide. The northern boundary runs very roughly from the mouth of the Senegal River through Lake Chad and Lake Rudolf to the coast of Italian Somaliland, and in the south the boundary bisects Angola, runs southward along the boundary between that territory and Northern Rhodesia, and then bisects Southern Rhodesia and Mozambique, west to east. The bulk of the land between the boundaries is infested by one or more of the twenty-one species of *Glossina*, and consequently by trypanosomiasis of domestic animals and of man, diseases which are transferred from host to host by the fly.

In the British territories, trypanosomiasis of cattle, often called Nagana fever in Eastern Africa, affects a very wide area, particularly in Tanganyika of which two-thirds is under fly, the Rhodesias, Nigeria, and the Gold Coast. In these territories the treatment of the disease and possibilities of fly control occupy much of the attention of veterinary departments, and of the special Tsetse Department in Tanganyika. Study of this problem has served to show its great complexity.

Human trypanosomiasis (sleeping sickness) is due either to *Trypanosoma gambiense* or *Trypanosoma rhodesiense*, and the two forms of the disease are now known to involve rather different problems. *Gambiense* transmission has been shown to be from man to man, through the agency of tsetse fly; *rhodesiense* is probably disseminated in the same way, but it is also thought to be capable of transmission by wild animals which carry it in a dormant state. Hence in the control of the latter type of sleeping sickness, which is prevalent

in Tanganyika, it has been considered important to bring natives out of scattered villages in fly-infested woodland, and to establish them in large clearings where the fly cannot live.

The organizing centre for research in British Africa is the Tsetse Fly Committee of the Economic Advisory Council, which, like the Committee on Locust Control, was created in 1925, as a sub-committee of the Committee of Civil Research. Its report (1933) on developments in the treatment of human and animal trypanosomiasis and in tsetse fly control in the period of 1925–31, represents a valuable summary of the position. The special problems of trypanosomiasis and tsetse fly control in Tanganyika, have more recently been under examination by a sub-committee.

Mr. C. F. M. Swynnerton (1936), late Director of the Tsetse Research Department in that territory, wrote a monumental work on every aspect of tsetse flies in East Africa. The bulk of the volume is devoted to detailed accounts of results of work in Tanganyika, mainly during 1931 to 1934, but the position in other East African territories is summarized. Since this can easily be referred to, only the most important results of work in Tanganyika will be mentioned here, and the original publications of members of the tsetse department are not included in the bibliography except in a few cases such as the work by Potts (1937) dealing with the distribution of tsetse flies in Tanganyika, published since Swynnerton's volume. For Southern Rhodesia and Nigeria where there is no such published account the position is described more fully.

Methods of control by the reclamation of areas which have hitherto been overrun with fly, are being developed in three principal areas of British Africa: in Tanganyika by the special Tsetse Department under Mr. C. F. M. Swynnerton[1]; in Southern Rhodesia under Mr. R. W. Jack, the Government Entomologist; and in Nigeria, where there is a Sleeping Sickness Branch of the Medical Department, with Dr. T. A. M. Nash[2], as Entomologist. Results from each of these areas are reviewed briefly below. Considerable success has been achieved, but it is important to bear in mind,

[1] While this volume was in the press the tragic news was received that Mr. Swynnerton, together with Mr. Burtt, botanist in the department, were killed in an aeroplane accident near Shinyanga in May 1938.

[2] Formerly a member of the tsetse department in Tanganyika.

MAP 2. The distribution of the Tsetse Flies in Africa. (*After Swynnerton, 1936.*)

in view of the growing importance of soil erosion in Africa, that unless or until the areas reclaimed from tsetse fly can be protected from misuse, reclamation may defeat its own ends.

The eradication of the flies may be sought through the destruction either of their food supply, or of their habitat. Attempts to starve the flies out of wide areas by wholesale *destruction of animals* have been tried in several places, as mentioned in Chapter VIII, but, except in Southern Rhodesia, such methods have proved either impossible or undesirable. In Tanganyika experiments and observations have been initiated on the relations of the flies with their food-animals, and the conditions under which control of the latter may be necessary.

Flies can be completely eradicated from any country by *clearing the vegetation* with the axe, but this method has serious drawbacks: among others, its employment on a large scale is prohibitively expensive. Nevertheless, remarkable results have been achieved, especially in the Shinyanga district of Tanganyika, where the natives have been induced to reclaim their land by voluntary labour. For the past nine years thousands of natives have turned out annually for a fortnight's clearing work, with the result that large areas have been reclaimed. Up to 1933 some 5,000 natives had been able to return to land in one chieftainship from which they had previously been driven by an advance on the part of the flies. Eradication of fly by organized grass fires without clearing the bush, which has been very effective, has limitations, in that continuity of the grass cover must be adequate for successful burning; but there are said to be many hundreds of square miles in Tanganyika and Southern Uganda suitable for this method of control. Fires are permanently effective only if they can be carried up to and across barriers impassible to fly. Such barriers have been provided in part of Tanganyika by clearing broad bands of vegetation, the country being thereby divided into blocks, in each of which the fly can be attacked with no risk of reinfestation.

As a subsidiary method of attack, remarkable advances have been made in the wholesale catching of fly by *traps*. A trap patented by Mr. R. H. Harris has been tried extensively in Zululand and now in parts of the Congo; others, devised on a different

principle and at lower cost, have been the subject of experiment by the Tanganyika Tsetse Research Department for some years. This department has also devised screens on which the flies are caught by hand, and which, carried about through the concentration grounds of the flies, are more effective than any trap, and like the traps attract great numbers of female flies.

It has been surmised from laboratory experiments that the females are apt to be so pestered by males whenever they appear that abortion and sterility may result. Hence it has been suggested that only females should be caught and killed. An experiment to test this hypothesis was prepared in Tanganyika: females were to be caught and killed, all males to be liberated, and also large numbers of males were to be imported. The latest observations, however, suggest that the hypothesis is unfounded, besides which the skill of the females in hiding away would probably defeat the experiment.

Two members of the tsetse department, T. A. M. Nash and C. H. N. Jackson, have shown that most species of tsetse flies have permanent or seasonal *foci of concentration* where environmental conditions are most suitable for them, and that *G. morsitans* has also foci that are merely its feeding-grounds. During the rainy seasons the flies spread into the surrounding country from these foci, to which they are driven back by harder conditions in the dry seasons. Attacks directed against these centres will, therefore, produce the maximum results. It has been shown that trapping by itself, however intensively concentrated, can never effect complete extermination even in the case of *G. pallidipes* and *palpalis*.

Another recent discovery of importance is that of the effects of *densification of vegetation*. Experiments in Tanganyika have shown that, if a patch of tsetse-infected bush is protected from fires for several seasons, the growth becomes so dense as to be highly unfavourable to certain species of fly. Thus in one block of four square miles which was protected from fire for three years the numbers of *G. swynnertoni* were reduced by nearly 70 per cent., although the game in the area increased slightly in the same period. At the same time in a second block, where grass burning proceeded normally, the flies increased by over 300 per cent.

The above brief outline of the practical results achieved by the

tsetse department includes few of the ecological discoveries on which their methods are based. Fly ecology is being studied intensively by a research staff, consisting of three entomologists, a general zoologist and a botanist, and includes researches on the species of principal importance in the territory—*Glossina morsitans*, *G. swynnertoni*, *G. pallidipes*, *G. austeni*, and *G. palpalis*. The subjects of research fall roughly into three categories: 1. Association of tsetse with physical and biological complexes of the environment: relations with man, animals, plant communities; the effects of seasonal change, parasites, predators, and fire. 2. Experimental alteration of physical and biological environment: by firing grass and bush, altering plant succession, altering the animal population qualitatively and quantitatively. 3. Biological control: nothing of real value is yet known, though two parasites have been tried, one of them exhaustively.

In Southern Rhodesia the main tsetse fly problem is created by the tendency of *G. morsitans*, which disappeared from the vast tracts of country after the rinderpest epizootic in 1896, to spread from the small areas where it survived. Portions of the country from which the fly receded have been occupied by European agriculturalists and in most of this potential fly area natives have acquired cattle. Whilst the natives in these areas have mostly lived in fly country for generations, and suffer the loss of the cattle they have acquired without exhibiting any desire to leave their ancestral homes, European settlement is inevitably driven back before the encroaching fly. Contact between fly and European settlements was first established in 1918, since when some farms have been evacuated and a great many more have been threatened with disaster. To give some idea of the rate of fly encroachment, at one time it was estimated that the pest was adding about 1,000 square miles to its territory annually.

The country actually infested with tsetse at the present time lies mostly at low altitudes and includes the Zambesi valley. For reasons of climate and of its poor fertility, this land is unfitted for European occupation, and is capable of supporting only a small and scattered native population. Only small areas are worth heavy expenditure, and at present there is insufficient pressure of population, either European or native, to make urgent the recla-

mation of even the limited fertile tracts. The immediate problem is therefore one of defence rather than of attack. It is not the 20,000 square miles of actual fly area with which the agricultural department is concerned, so much as the 30,000 square miles of more valuable country in the northern part of the territory, which the pest has threatened to overrun. The fly front extends for about 600 miles from the Wankie district in the west to the Darwin district in the east. Some 150 miles of this front are held to be protected by physical features, so that about 450 miles remain to be defended.

In view particularly of the ruin and dislodgment of European settlers, prompt and effective action, of an extensive rather than an intensive nature, had become imperative some years ago. The only measure which seemed likely to achieve the object in view within a sufficiently short period, and without involving excessive expenditure, was to drive back the game by organized hunting, in the hope that the fly would retire from country depleted of its food. At the present day a cordon, in which the game is kept at a minimum by controlled hunting, is maintained along practically the whole of the 450 miles of open fly front.

The experiment has been carried out in the face of criticism both in Rhodesia and elsewhere, but the results, which are described by Jack (1933, 34, 35a) and Chorley (1936) have been satisfactory. Trypanosomiasis due to *G. morsitans* has now been practically eliminated from areas in European occupation; the advance of the fly has been changed to retreat; over 2,000 square miles of country have been freed from the pest, or at most are subject near their limit to the intrusion of an occasional fly from the infested country beyond; and cattle are now running freely in areas from which they were eliminated by the encroaching fly comparatively few years ago.

A smaller problem of a different nature exists along a short section of the Southern Rhodesian-Portuguese border in the Melsetter district. The Rhodesian side of the border has been subject to incursions of fly, mostly *G. pallidipes* from Portuguese territory. Some farms have been evacuated on account of the heavy mortality of cattle. It was decided to try the effect of a forest clearing along the border, an undertaking which was rendered feasible by

the fact that not more than 10 per cent of the ground was covered by continuous forest. The clearing, which varies in width up to about a mile, was begun in 1932, and by 1934 had been extended to a length of some thirty-five miles. Indications to date show that it has been remarkably effective: trypanosomiasis has died down to near the vanishing point on the Rhodesian side of the border, and several evacuated farms have been reoccupied with considerable numbers of cattle.

Southern Rhodesia has a specific Tsetse Fly Act (1929), which empowers the Government to control traffic leaving the fly area and to rid it of any accompanying flies. On routes which carry wheeled traffic, suitable chambers are erected for the treatment of motor vehicles with petroleum-pyrethrum sprays. There is a gauze-covered ante-chamber, in which any flies which leave the vehicle can be caught. On routes carrying only pedestrian and cyclist traffic, smaller gauze cages are provided and native guards are on duty at each station. Fourteen such stations have been established, but with the gradual retrogression of the fly, three have already been discontinued, and there is a prospect that six or seven more will follow at an early date.

Whilst the measures put into operation against the encroachment of *G. morsitans* in the territory have been conspicuously effective, the constant destruction of wild life is highly repugnant, and it is felt in Southern Rhodesia that every effort should be made to discover alternative measures which can be used gradually to replace the game cordon, now that the flies' advance has been controlled. Field work in the nature of superficial observations, but including the discovery of the natural breeding sites of *G. morsitans*, has been proceeding in the colony during the past quarter of a century, whilst more detailed work in reference to the bionomics of the fly, studying the effect of delayed and controlled grass fires, seeking measures of biological control, testing the Harris and other traps and so forth, has also been carried out from time to time. Funds have now been provided for continuous laboratory research into the effect of environmental factors, particularly temperature and humidity, on the vital processes and behaviour of the local tsetse. Most of the necessary apparatus has now been assembled at Salisbury, and some progress has already been made. It is hoped

that this laboratory research may point the way to promising lines of investigation later under field conditions, which may lead to something practicable in the way of alternative measures of controlling *G. morsitans.*

In Nigeria the problem of tsetse research is rather different, being at present connected more with trypanosomiasis of human beings than of cattle. The medical aspects of the problem are considered in Chapter XVI. A special Sleeping Sickness Service, which includes entomological research, is maintained by the Medical Department. Dr. Lester is in charge of this, with offices at Kaduna, the capital of the Northern Provinces, and a laboratory is maintained at Gadau, with a medical officer and an entomologist, Dr. T. A. M. Nash; a second entomologist has been appointed from 1938. There are only three species of *Glossina* in Nigeria of economic importance: namely *G. morsitans*, *G. tachinoides* and *G. palpalis.* Of these *G. morsitans* is the least important because it only occurs in very thinly populated areas where big game still survives in large numbers. *G. tachinoides* and *G. palpalis*, on the other hand, thrive in the densely populated areas where man and reptiles form the primary food supply. Since big game is the reservoir from which tsetse become infected with the trypanosomes that affect domestic animals, it is mainly in the thinly populated areas that the fly are highly infected—areas in which little damage can be done. Probably the bulk of cattle trypanosomiasis originates when the Fulani drive herds of cattle along trade routes through these big game areas. Owing, however, to the dense population in most parts of Nigeria, which limits the areas where big game is abundant, cattle trypanosomiasis presents less serious problems than elsewhere in Africa.

In the Northern Provinces all three species concentrate in the dense vegetation bordering streams and rivers, to which they are driven by the intense heat and desiccating atmosphere of the open country. Since the wet season in that country is very short, fly cannot spread far away from the streams before the next dry season drives them back to the riverine vegetation. The distribution of *Glossina* is thus linear, following the streams, and the intervening country is fly-free. The enormous fly belts typical of Eastern Africa do not occur, solely because the West African dry season is

so severe that the woodland savannah cannot support the tsetse.

The primary carriers of human trypanosomiasis are *G. tachinoides* in the Northern Provinces and *G. palpalis* in the Southern, which can exist and thrive in thickly populated areas. There is an intermediate zone where both species are of nearly equal importance. Up to 1931 it was thought that sleeping sickness occurred in definite belts throughout Nigeria, and that continued campaigns for medical treatment would reduce it to control. It has since been found, however, that sleeping sickness is not limited to fixed belts, and that the proportion of infected people in certain provinces, notably Zaria, where over a quarter of a million people have been examined and 20 per cent. were found to have sleeping sickness, is far too high to be controlled except by a very large organization. There is evidence, moreover, that the incidence of the disease has increased considerably in Nigeria under British occupation, since, under its greater security, the people have left their large villages and have scattered into small bush-hamlets, thereby coming into more frequent contact with the fly. Accordingly the Colonial Development Fund has accepted an application for assistance in a large sleeping sickness and tsetse campaign, to include an extension of the present research organization.

It is clear that protective measures, aiming at reducing the man-fly contact, give the most hopeful lines of attack. The eradication of fly from native villages by clearing the banks of streams is an essential measure. Some provision for this has been made in the new Sleeping Sickness Ordinance (Nigeria 1937), partly based on the Uganda Ordinance, which has been acted on for many years.

The choice of methods to be employed against the fly depends, of course, on the results of research into the ecology of the flies. The original researches at Gadau, carried out by Drs. Lloyd and Johnson (now Sir Walter Johnson) (1923), provided a general survey of the problem in Northern Nigeria. The work of Nash (1930, 33, 34, 35, 37) during the past few years is of special interest in relation to control measures. His studies of the climates in the environment of the flies, both in the field and laboratory, show that the maximum shade temperature which *G. morsitans* and *G. tachinoides* can withstand is 106°F., and since this temperature is often exceeded in the woodland in the drier parts of Nigeria, the fly

must resort to the shade of dense vegetation along streams in order to survive during a large part of the dry season. Accordingly conditions are less favourable to the fly in Nigeria than in Tanganyika, where it need never leave the woodland.

For these reasons, if the stream-banks were cleared wherever native villages are situated, those villages would become practically free from fly; man-fly contact would be decreased, and a few human carriers would no longer be a menace to the rest of the inhabitants. But far more efficient and easier to control would be the concentration of population in each district into a central area where all streams were cleared. These settled areas would be linked together by trade routes rendered fly-free by clearings made at all places where the path crosses streams clothed with riverine vegetation. The success of such projects will depend to a large extent on improved methods of agriculture, which will keep the land in permanent cultivation; these methods which include mixed farming and ploughing with oxen are under investigation by the agricultural department in Nigeria; they are considered in Chapter XI.

In the Southern Provinces of Nigeria, where *G. palpalis* is the prevalent species, the whole problem is different. Sleeping sickness seems to have been endemic there for a much longer period, so that the population as a whole has acquired a measure of resistance. The possibility of control by modifying vegetation is less in this region; the rate of growth is so great that it is impossible to keep any area in the rain forest belt thoroughly clear of vegetation. Yet the densification of vegetation is also difficult to organize, since wherever man exists he cuts down the forest growth for purposes of shifting cultivation. Here, as in the north, efforts to concentrate the population and to introduce a settled system of agriculture appear to offer the best hope of controlling the fly.

Another important piece of work was carried out at Gadau by Professor P. A. Buxton and Mr. D. J. Lewis (1934) of the London School of Hygiene and Tropical Medicine, during a few months' visit. By breeding tsetse in the laboratory under controlled conditions they confirmed the view that humidity is the principal limiting factor for reproduction. Temperature is also important, and at certain times of the year under natural conditions the surface temperature of the soil is so nearly lethal to pupae that partial

bush clearing would probably be sufficient to eradicate fly. This was demonstrated also by Nash in Tanganyika, by exposing pupae in the bush at different depths in the soil.

The Nigerian forestry department has also for some years been studying the relation of forest protection to tsetse control and has urged that scattered villages in tsetse fly areas should be concentrated and the remaining forest land proclaimed Forest (Tsetse) Reserves, in which experiments in protection by densification of vegetation and grass-burning should be undertaken.

The fact that tsetse flies have received more attention in Tanganyika, Southern Rhodesia, and Nigeria gives the impression that the actual problem is more important in these territories than elsewhere. This is probably not the case, however, though governments in other territories have not yet come to regard the problem as one for immediate attack, for various reasons. Thus in Northern Rhodesia, Captain Pitman (1934) concluded from his faunal survey that the tsetse problem looms just as large as in the neighbouring territory of Tanganyika. It seems that no intensive survey of the position in Northern Rhodesia has been carried out, but it is generally assumed that fly has made encroachments in two areas with heavy loss of cattle.

Work in East Africa is referred to and summarized in the proceedings of the conference on the co-ordination of tsetse and trypanosomiasis research, published by the Conference of East African Governors (1936). In Nyasaland the medical entomologist, Mr. W. A. Lamborn, centred at Fort Johnson, works on fly and sleeping sickness from many points of view. Among other studies he has proved, in collaboration with Professor J. G. Thomson of the London School of Hygiene and Tropical Medicine, that trypanosomes can be transferred accidentally by flies which do not suck blood (1934). In Kenya several experiments on measures of control are in progress, involving co-operation between the division of animal industry, the medical department and the tsetse fly department of Tanganyika, and the medical entomologist, Mr. C. B. Symes (1935), has summarized the work on *G. palpalis* in Kenya. An experiment on the use of traps against *G. palpalis* is taking place on an island in Lake Victoria near Kisumu. The area of the Lambwe River in North Kavirondo,

which was highly populated prior to 1902 but has since been entirely depopulated, is also the site of a campaign against *G. pallidipes*. The riverine woods are being split into blocks by clearings at fords, and then the flies are eradicated by traps and hand-catching from each block separately. In this locality the aerial survey, made in connection with the Kakamega mining area, has proved invaluable. One of the entomologists from the Tanganyika department has also been stationed at Kilifi on the Kenya coast for research work on *G. pallidipes*.

In Uganda, after the historic epidemics of sleeping sickness at the beginning of the century, much pioneer work was carried out on tsetse flies by Bruce and others, and, as a result, the entire native population was evacuated from large areas bordering the great lakes and rivers, and including several of the islands in Lake Victoria, these regions being declared tsetse reserves. In this work the name of Dr. (now Professor) G. D. Hale Carpenter figures prominently. Dr. Duke and the staff of his laboratory for research on trypanosomiasis carried out fundamental investigations up to 1935, when the laboratory was closed down. Present work on fly by the government officers is restricted mainly to the application of existing knowledge to local problems. Organized fires, carried out by the veterinary department over many districts, have proved their value in reducing the incidence of fly, and a map of the Protectorate, showing the distribution of *G. palpalis* on the lake shores and rivers, *G. morsitans* in the south-west, west Nile, and part of the Northern Provinces, *G. pallidipes* in the south-east of the Eastern Province and in the Toro district, and *G. fuscipleuris* in the forests of the Western Province, has been published (Uganda 1934, D.R. p. 18). Experiments have been carried out on the use of artificial shelters for trapping pupae, and also traps for flies. In 1935–7, Dr. Mellanby has been in Uganda experimenting with *G. palpalis*. The results (Mellanby 1936 and 1937) may cause some change in outlook on the control of this species of fly, in particular with regard to the size of clearings required at river crossings and watering places.

In the Gold Coast the conditions appear to be very similar to those of Nigeria. In the dry Northern Territories the chief problem seems to be that of *G. tachinoides* and *G. morsitans*, while the more

densely vegetated Ashanti and the Colony itself provide a suitable environment for *G. longipalpis*, which renders the keeping of cattle out of the question, except for the dwarf breeds which are resistant to trypanosomiasis. Research here has been carried out by the veterinary department at Pong-Tamale, under Mr. J. Stewart, who has produced a report on the work (1937). Studies of tsetse have been made, and it has been established, as in Nigeria, that the fly occurs along the rivers except during the rainy seasons when it migrates into the dry country. An intensive study has been made also of the trees and other vegetation of the savannah, known locally as orchard bush, and as a result, a system of clearing has been worked out on the area of country grazed by the herds of cattle kept at Pong-Tamale: belts of land half a mile wide are cleared along the water-courses, and the brushwood is burned over the stumps of those trees which are most capable of rapid regeneration. It is claimed that this clearing along streams can be carried out at a very low cost. Nearly the whole area of the Pong-Tamale farm has been rendered free from fly, and losses from trypanosomiasis among the herds have been reduced to a very low level (Plate iv, p. 296.)

In those colonies comprising French West Africa, where sleeping sickness is prevalent, intensive treatment campaigns have been carried out, as described in Chapter XVI. The distribution of fly has been ascertained in many areas by special missions sent out for the purpose, notably those of Mm. Bonet, Roubard, and Jamot during 1906–16 and 1932–5. A map (*Afrique Occidentale français* 1935) has been published, showing the available data for all the West African territories from Nigeria to Senegal.

If it is legitimate to generalize on a subject so complex, it appears that in West Africa there has been some hesitation in embarking on the expenditure involved in bush-clearing and similar anti-fly methods, while research work has been concentrated on the development of medical treatment of sleeping sickness. It seems probable, however, that large-scale anti-fly work such as that of Tanganyika will eventually become essential, and will call for the organization of special departments. It is sometimes suggested that the methods of control discovered in Tanganyika can be applied in other territories without any special organization. This, however, is only

partly true, since much of the laborious research work has to be repeated for each kind of environment and for each association of tsetse species. In West Africa, therefore, it appears that further development of research organizations is called for, while in East Africa the field problems have reached a stage of research when they can profitably be taken into the laboratory for controlled experiment, such as has already been described.

INSECT PESTS OF CULTIVATION

A brief review of so wide a subject as this must be limited to major pests and to the branches of research which are obviously important. Even within these limits it must aim rather at indicating the kind of work that is being done than at the evaluation of achievements. The following paragraphs are therefore illustrative, rather than critical, and the facts mentioned are intended more as examples of important lines of research than as an account of all the valuable work that has been done. It is impossible to do more than mention, for instance, the necessary routine work of entomologists who succeed, for the most part, in keeping within reasonable bounds insect pests that cause a fairly regular loss to the major crops. The time which agricultural entomologists have to spend in such work limits their research to experiments centred on routine duties, and to the discovery of ways of controlling sudden and destructive infestations.

It is obvious that in Africa large distances, poor communications and often sparse population make field work far more difficult and irregular than it is in Europe. But what limits research and the application of experimental results more than anything else is the ignorance of the native population. Control measures requiring methodical care and precision, which are confidently recommended to growers in the United States, for example, cannot be entrusted to uneducated natives. The fact that even in such a highly developed country as Egypt all fumigation has to be carried out by special Government officials illustrates the difficulty of popularizing such control measures. Some idea of the general nature of such difficulties and of the means adopted to overcome them may be obtained from the reports of the Conferences

on veterinary and agricultural research in East Africa (1934a, 1934b).

In the following notes the different crops are treated in the same order as in Chapter XII, where other aspects of crop research are considered. Frequent reference is made to the results of researches which fall into the botanical rather than the entomological field, particularly to work on virus and other diseases which are transferred from host to host by insects.

Cereals

The typical native cereals such as millets and guinea corn seem to have attained a partial balance with the pests of Africa. Insects cause considerable local loss to such crops, but the fact that they are grown in small plots renders dispersal difficult for the pests. The extensive growing of cash-crops, particularly those recently introduced and having no natural immunity to local pests, such as maize and wheat, gives opportunities of which Africa's insects have not been slow to take advantage. Most of the entomological work has been concerned with maize which is grown far more extensively than other introduced cereals.

Several of the polyphagous insects such as *Heliothis obsoleta* and *Prodenia litura* have some importance as pests of maize. But most of the research on these two moths has been carried out in connection with cotton (see below).

In South Africa the most persistent pest is the maize stalk-borer (*Busseola fusca* Fuller). The control measures usually recommended are mostly cultural, and include top-dressing with derrisol, the destruction of crop-refuse during the winter and the avoidance of early planting. Creolyte, however, has been found to be a powerful stomach poison and suspensions of it spread on the tops of the maize have been very effective (Mally 1920, Ripley and Hepburn 1930, 1934). *Busseola* produces a second generation on sorghum in South Africa, and trap-crops have been suggested as a possible control measure.

A virus disease of maize, known as streak disease, is common in South and East Africa. Experiments at the Amani Research Station, directed to the study of the fundamental nature of virus disease as exemplified in tropical crops, have shown, incidentally,

that the Jassid bug, *Cicadulina mbila* Naudé, and two other species of *Cicadulina* are vectors of this disease of maize (Storey 1925).

It is convenient to notice here experiments on the transmission of mosaic and streak diseases between maize and suger-cane. In the Transvaal a strain of mosaic was found that would not infect sugar-cane, though virulent to maize and sorghum (Storey 1929). In the case of streak diseases there are two distinct viruses, virulent respectively to sugar-cane and maize, both transmitted by *C. mbila*, and both producing permanent infections in the hosts to which they are specialized. The cane virus produces only a mild form of the disease in maize, whereas the maize virus produces only a transitory infection of cane, from which the plant recovers (Storey and McClean 1930).

In Southern Rhodesia, in addition to the above-mentioned pests, the young maize plants are subject to attack by Snout Beetles (*Tanymecus destructor* Mshl., and *Systates exaptus* Mshl.) (Jack 1935b) Cutworms, wireworms, crickets, and grasshoppers, most of which can be poisoned, are also troublesome. More difficult is the problem presented by the outbreaks of white grub (*Eulepida mashona* Arrow), which seems to be specially associated with ground of which the humus content has been artificially increased, as mentioned in the annual report of the Chief Entomologist, Mr. R. W. Jack (1935b).

Oil-seeds

The polyphagous pests of cotton, *Heliothis obsoleta* and *Prodenia litura*, do a certain amount of damage to *groundnuts* in various parts of Africa, but the central problem of entomological research is the rosette disease. During the last few years many experiments have been made and at least two insects have been shown to be vectors. *Aphis laburni* Kalt. has been found to transmit the virus experimentally (Trochain 1931, Storey and Bottomley 1928), and this aphid is found in association with the disease in Gambia, Senegal, South Africa, Sierra Leone, Nigeria, and Uganda. In French West Africa sprays of kerosene and soap free infected plants from aphids and allow them to recover at least partially, but observations elsewhere in West Africa, especially in Sierra Leone, do not confirm this result (Bouffil 1933). The French investigators have

also worked on the control of the aphids by predatory insects, especially the Coccinellid beetle, *Cydonia vicina* Muls. (Vuillet 1934). There appears to be some doubt as to the possibility of breeding resistant strains: some investigators have found some strains more resistant than others, but resistant strains were not observed in French West Africa during 1933, as noted by Bouffil (1933). Strains resistant in one environment are not necessarily resistant in others and thus the prospect of reducing damage by the disease in this way is limited. Work on such lines must be done in the territories concerned and probably in various regions. In addition to *Aphis laburni*, it is suspected that the whitefly, *Bemisia gossypiperda* var. *mosaicivectura* Ghesq., may also transmit rosette disease. The virus apparently overwinters in diseased plants that germinate in late autumn (Storey and Bottomley 1928), and one of the control measures suggested by these researches is to destroy all plants between growing seasons. In Nigeria, Uganda, and the Gambia the close spacing of plants and controlled maintenance of weed growth between the plants, so as to produce a complete ground cover, have been proved markedly to reduce the incidence of rosette disease. Possibly, though the fact is not yet established, there is control of the insect vector in the damp atmosphere created by close planting, by means of some entomogenous fungus.

Cotton

Bollworms are almost universally distributed throughout the cotton-growing area of Africa, and in spite of considerable research few sure means of control have been found. Attempts at biological control have at best attained variable success. For instance, a large percentage, generally higher on maize than on cotton, of the American bollworm (*Heliothis obsoleta* F.) is parasitized by *Trichogramma luteum* Gir. in Southern Rhodesia, but attempts to establish this parasite in the Transvaal have failed. Similarly, an effort to increase the effectiveness of *Microbracon kirkpatricki* Wilksn., a parasite of the pink bollworm (*Platyedra gossypiella* Saund.) gave doubtful results. In Uganda intensive work on possible parasites and alternative hosts of this pest is in progress. Work with bacteria against the pink bollworm (Metalnikov 1933) remains in the experimental stage. Chemical measures are for the most part

impracticable or useless, although dusts of calcium arsenate were fairly successful against young larvae of *Heliothis* in Rhodesia. Cultural measures, intended rather to check than to eradicate the pest, seem to have given the best results under African conditions.

Outbreaks of the American bollworm are largely determined by weather, and the presence and condition of its alternative food-plants. Where no winter crops are grown in irrigated areas, infestation is often comparatively slight. Recent investigations (Empire Cotton Growing Corporation 1934a and 1934b–38) on its bionomics suggest that the moths migrate not only from maize to cotton as has generally been thought, but from cotton to maize, and that they might, therefore, be diverted to maize under ordinary conditions. The moths are associated with maize only when it is in tassel, and planting should therefore be arranged to give overlapping flowering periods. Cotton should be planted early, so that as many bolls as possible may set before the moths come from the maize, and during the critical period other farm crops should be in the stage that attracts the moths. J. S. Taylor (1932) has investigated this pest and its parasites in South Africa. There is some possibility of breeding strains of cotton resistant to American bollworm; in this progress has been made in Uganda.

The chief cause of the spread of the pink bollworm is the extensive transport of seed cotton for ginning. The enforcement of a close season for cotton seems to be of the utmost importance. In the Sudan (Cowland 1933) regulations providing for a dead season of several months and for the proper disposal of the crop and storage of the seed have rendered the bollworm unimportant, except in areas where it can survive in cotton stored for local spinning and weaving. Disinfecting the seed with hot air has been successful in Egypt and elsewhere.

Measures against the red bollworm (*Diparopsis castanea* Hamps.) seem very unreliable, but in the Sudan irrigation before ploughing has been found to destroy many of the pupae. It is generally thought desirable to avoid the late planting of cotton, and traps of standover cotton may reduce infestation. Smith (1933) has carried out research on this pest in South Africa. Another bollworm (*Earias insulana* Boisd.) is widely distributed and difficult to control. In the Sudan attempts have been made to encourage its

parasite, *Microbracon kirkpatricki*, by means of an alternative host.

The cotton worm (*Prodenia litura* F.), described by Bishara (1934), is a major pest in Egypt, Tanganyika, French Equatorial Africa, and Italian Somaliland. It feeds on the leaves and by weakening the plants renders them more susceptible to bollworms.

It appears from the reports received by the Empire Cotton Growing Corporation from Experiment Stations (1934b–38) that cotton stainers (*Dysdercus spp.*), bugs which transmit *Nematospora gossypii* and *N. coryli*, seem to be best controlled through their alternative food-plants, the wide range of which allows a long breeding season. In Rhodesia they migrate from early-flowering *Hibiscus* and from *Thespesia* to cotton in February, and return in May to late-flowering *Hibiscus*. In an area free from *Thespesia* the stainers appeared on cotton too late to cause much damage. In the Sudan, spraying baobabs (*Adansonia digitata*) with kerosene ten days after burning the cotton gave fairly good control. Some account of stainers in South Africa is given by Ullyett (1930).

The cotton whitefly (*Bemisia gossypiperda* Misra and Lamba) is a serious pest in the Sudan, Tanganyika, Southern Rhodesia, and the Belgian Congo. It has been thought that it transmits the disease known as leaf-curl of cotton (Kirkpatrick 1930, 1931), but in Tanganyika there are indications that the latter is due to a capsid. In the Sudan whitefly is sometimes checked by natural enemies after the winter. Since direct control is impracticable, experiments have been made to produce resistant strains of cotton, and two such strains of Sakel cotton have been bred successfully in the Sudan, and one Ishan strain has been grown for the last nine years in Nigeria, where the local vector of leaf-curl was discovered in 1929.

Capsid bugs of the genus *Helopeltis* are widely distributed over the western part of Africa and in Uganda. Attack by *Helopeltis* on cotton leaf and stems produces respectively spots and lesions which are difficult or, when old, impossible to distinguish from those caused by *Bacterium malvacearum*, which latter are known respectively as 'angular leaf-spot' and 'black-arm' diseaes (Hancock 1935 and Steyaert and Vrydagh 1933).

Jassid bugs known as leaf-hoppers (*Empoasca fascialis* and other spp.) have been serious pests in many parts of Africa; they may be

the vectors of a virus disease. The breeding of resistant strains, however, notably that known as U4, has reduced the importance of these pests.

Among other important pests, the cotton leaf-roller (*Sylepta derogata* F.), for which trap-crops of *Hibiscus* may be useful, is very widely distributed. *Lygus simonyi* Popp. causes considerable damage in Uganda, and in the Sudan several species of Thysanoptera, especially *Hercothrips* spp., retard the growth of the plants.

Root crops

Considerable attention is being given to the pests of root crops for native food as well as to those of export crops. The work done in Nigeria, described by O. B. Lean (1928), when the damage to yams by a Dynastid beetle, *Heterolygus claudius* Klug, was so severe during 1925–7 as to cause a famine, may be cited as an example of such research. More recently a mosaic disease of cassava has been the cause of serious loss to native food crops both in West, East, and South Africa. The disease did not make its appearance in West Africa until 1929 and is thought by some to have been introduced. The insect vector has been proved in Nigeria, at Amani, and elsewhere to be a species of whitefly (*Bemisia*). The most hopeful line of control is the breeding of resistant varieties of cassava (*see* Chapter XII). The cultivation of native food crops usually differs from that of export crops in that a mixture of crops is planted on one plot. Mixed cropping may be a defence against serious outbreaks of pests, so that many remain unnoticed or unimportant until the system of agriculture is changed.

Coffee

Among the chief pests of coffee in East Africa are Pentatomid bugs of the genus *Antestia*, especially *lineaticollis* Stol. Biological control, even in Kenya, where the eggs of this bug appear to be most heavily parasitized, is not sufficient to keep infestation within bounds. A considerable amount of work on chemical control has been done in that colony, where pyrethrum-kerosene sprays seem to have been very effective (Le Pelley 1932). Bait-sprays containing sodium arsenite and sugar are sometimes preferred, but it is thought by some that their use is likely to lead to heavier infes-

tation by the coffee leaf-miner (*Leucoptera coffeella* Guer.) through the destruction of its parasites. Bait-sprays have given variable results, a reason suggested is that they destroy the parasites of *Antestia* (Le Pelley 1933). There is also a considerable risk of scorching the foliage, but in Tanganyika it has been found that this can be avoided by using triple-strength arsenic bait-spray through an improved fog-sprayer.

The coffee capsid (*Lygus simonyi* Reut.), another bug distributed throughout the coffee-growing areas of East Africa, injures the flowers so that the fruit does not set. It is satisfactorily controlled by pyrethrum-kerosene sprays in various forms. These sprays, however, probably interfere with Coccinellid beetles controlling *Pseudococcus kenyae* Le Pelley, a mealy bug which is not susceptible to the spray and which was formerly recorded under the name *Pseudococcus lilacinus* Ckll. *P. kenyae* is probably the most important of a number of destructive mealy bugs, the identity of which is still doubtful. In Kenya banding trees with kresotow and castor oil against the ants which foster mealy bugs has been found successful (James 1932). Mealy bugs are almost universally distributed in coffee-growing districts.

Another widely distributed major pest is the coffee berry-borer (*Stephanoderes hampei* Ferr.). In Uganda and the Belgian Congo a considerable measure of control is exercised by parasites, of which the most effective is the Bethylid, *Prorops nasuta* Wtstn. *Heterospila coffeicola* Schmied. is also of some importance (Sladden 1934). Attention has been paid to the disinfestation of coffee beans: in Kenya it has been found that exposing infested beans to heat rids them of the borer, while in the Belgian Congo experiments have been made on the fumigation of seed intended for planting. Turpentine has been found to be a successful fumigant (Sladden 1932). In Nyasaland other pests, *Anthores leuconotus* Pasc. and *Thrips* are of importance.

In addition to the work on specific coffee pests, the fundamental researches of Kirkpatrick (1935) at Amani are most important. This work, which is mentioned in Chapter IV, is breaking new ground in demonstrating the dependence of pests on the micro-climates of their environment.

Cacao

In West Africa, where cacao is the chief export crop, the plants are infested by a large number of pests, two of which may be regarded as of major importance.

Thysanoptera of the genus *Selenothrips*, especially *S. rubrocinctus* Giard, are widely distributed and are very destructive. It appears that attack occurs under bad conditions of culture which can be correlated with faulty water relations between plant and soil. Control measures include cultural measures and the use of insecticides containing resins (Kaden 1934). The other pests against which special work has been necessary in the Guinea Gulf are capsids of the genus *Sahlbergella* (Cotterell 1930). These bugs are also destructive in the Belgian Congo. Experimentally, a nicotine spray was successful in the Guinea Gulf area, but it was found difficult to get it generally employed, and both nicotine and other effective sprays are little used commercially. Insect pests of stored cacao in the Gold Coast and elsewhere are mentioned later, but one of these, a weevil (*Araecerus fasciculatus* De G.), is known also to attack cacao in the pod in Tanganyika. The insect pests of cacao in French West Africa, especially the Ivory Coast, together with pests of other crops, are considered in a long paper by Mallamaire (1934).

Miscellaneous

Perhaps the most important of the pests of tobacco is the whitefly (*Bemisia*) which is the vector of leaf-curl, a virus disease in South Africa, Rhodesia, the Belgian Congo, Tanganyika, Nyasaland, and Nigeria. A similar disease has been recorded from Java, where it is transmitted by a species of *Bemisia*, not, however, the same species as that which experiments at Amani have shown to transmit the disease. It is thought by H. H. Storey (1932) that the species used at Amani is the same as that which is a vector in Rhodesia (*B. rhodesiensis* Corb.). A species of *Bemisia* has also been proved by Golding to transmit leaf-curl in Nigeria. In Rhodesia sprays of tobacco extract and Bordeaux mixture have been tried as control measures (Mossop 1932a), but the best control appears to have been established by legislation which requires all tobacco lands to be cleaned of plants by August 1st each year, thus leaving no reservoirs for the virus.

The tobacco capsid bug (*Engytatus volucer* Kirk.) punctures the leaves, and causes them to contract and crinkle (Roberts 1930). It is not a vector of the mosaic disease of tobacco, which has recently been proved to be *B. rhodesiensis* Corb. A measure recommended against it in Rhodesia is to plant in December so that the plants will be well established before the peak of infestation in April.

The most serious pest of tobacco in Southern Rhodesia and Nyasaland is probably the root-knot nematode (*Heterodera marioni* Goodey), which, although not an insect, falls within the province of the entomologist. A special investigation of this pest has recently been undertaken by the Tobacco Research Board. Other insects which attack tobacco in Rhodesia include cutworms (chiefly *Euxoa segetum* Schieff), Tenebrionid beetles, both as adults and larvae, a large cricket (*Brachytrypes membranaceus* Dr.), the stem borer (*Phthorimeaa heliopa* Lw.), and the splitworm (*Phthorimeaa operculella* Zell.). Tenebrionid beetles can be poisoned in the adult stage, and a bait consisting of barium fluosilicate and maize meal has given good results against the large cricket.

A virus disease of tobacco causing stunted growth and malformation of the leaves has been experimentally transmitted in South Africa by a thrips of the genus *Frankliniella*, which is close to *F. insularis* Frankl., the vector of wilt-disease of tomato in Australia (Moore 1933). The larvae were shown to contract infection from diseased tomato leaves, and the thrips infected several species of solanaceous plants, which may therefore serve as reservoirs for the virus.

Where infestation by insects causes a regular and known loss without provoking danger of the kind caused by virus diseases, it is enough to discover simple control measures that can be applied readily by native labour. For this purpose experiments are made to find suitable local adaptations of measures which are themselves not new in principle. In connection with the cosmopolitan pests of *Citrus*, for example, there is a continual search for satisfactory sprays, bait, and mechanical means of control. In Algeria there has been some work done on various oil sprays against Coccids on Citrus (Balachowsky 1933), and in the Union of South Africa, Dr. L. B. Ripley's new sodium fluosilicate bait for fruitfly has been

successful (Ripley and Hepburn 1935). There also, the codling-moth is being controlled by spraying, trapping, and hand-picking (Pettey 1932). In the less civilized parts of Africa, however, even ordinary simple methods of chemical control are beyond the resources of the cultivators, and the problem is thus in most cases rendered far more difficult because cultural methods of control, which include breeding resistant strains, have to be devised, and these must at the same time be fitted in with agricultural practice. For crops recently introduced, closer attention is necessary. As an example of this, investigations on the pests of tea in Nyasaland may be mentioned (Smee 1928, Smee and Leach 1932).

In the Union of South Africa parasites have been used in the biological control of pests as in the case of the eucalyptus snout-beetle, a parasite of which was brought by Mr. Tooke from Australia and has led to complete control. Attempts have been made to control the citrus mealy bug (*Pseudococcus citri*) with the *Cryptolaemus* ladybird beetle and the woolly aphid with *Aphelinus mali* (Smit 1934b). In 1935 Mr. G. A. Hepburn began work on parasites of the wattle bagworm imported from Madagascar. In South Africa also work is in progress on the biological control of prickly pear with *Cactoblastis cactorum*. This is in charge of Dr. Pettey, who has two entomologists and several assistants at the stations of Uitenhage and Graaff Reinet.

Termites

The probable effects of termites on soils, both in improving fertility by aeration and in reducing fertility by destruction of the grassland cover and in increasing erosion, and even perhaps in consuming humus, have been discussed in Chapter V. In view of the enormous numbers of these insects in all parts of Africa south of the Sahara, their influence on agriculture and the serious damage which they occasion to buildings, the amount of research carried out on them seems small. The few works that have been published come from South Africa. Fuller (1921 and 1922) has given a valuable account of the species with notes on the localities in which they are known, their nests, etc. From the same author (1924) we have an anatomical study of some species, and also an account of experimental tests on the resistancy timbers. More of

recently Naudé (1934) has studied these insects in relation to veld destruction and erosion.

It is commonly accepted that the staple diet of most species consists of wood, which these insects are able to digest through the agency of symbiotic Protozoa in their guts. Some kinds, however, have been known for a long time to store grass and other vegetation in special granaries partly for food, and partly to grow special crops of fungi underground. Naudé considers that in South Africa grass provides much the largest part of their diet. Dividing termites first into two groups, the harvesters which feed mainly on grass and the fungus-growers which for the most part grow their own crops underground, he considers the damage done and the means of control. He concludes that the harvesters take a severe toll of the grass veld, particularly in drought conditions, but that they respond well to baiting, which appears to give relief from them. The grass-eating capacity of termites can be confirmed by observations in many parts of the continent; for example in Northern Nigeria fields of sown grass may be completely consumed by these insects in the course of a few days. The fungus-growers are relatively easy to control, but tend to be vainly attacked by farmers in the mistaken idea that they are responsible for the most serious veld denudation.

Even if wood is not the principal food, most termites will take to it whenever occasion offers, and this has led to endless expense in making buildings termite-proof and in substituting metal for wood as material for railway sleepers. A problem of growing importance is the damage done by these insects to landing-grounds for aeroplanes. Some species work rapidly in throwing up their mounds or termitaria and accordingly heavy expenditure on labour is necessary to keep aerodromes in condition.

Sericulture

Though not connected with pests or diseases, the silkworm must be mentioned in any discussion of Entomology. Sericulture has not yet attracted much attention in Africa, but there is no doubt that there is opportunity for a minor industry. In 1929–30, Mr. Norton Breton, Chairman of the Imperial Institute Advisory Committee on Silk Production, visited the Union of South Africa, Rhodesia,

and the East African colonies to investigate the possibility of sericulture in these territories. Practical results were prevented at the time by the economic depression, but developments may take place later.

INSECT PESTS OF STORED PRODUCTS

The problems involved in the storage of products such as cocoa and tobacco fall mainly in the provinces of Entomology and Mycology, and to study them a Committee of the Empire Marketing Board was set up in 1930 as an advisory body. Since then the headquarters of investigation in Great Britain has been Professor J. W. Munro's Department of Zoology and Applied Entomology at the Imperial College of Science and Technology at South Kensington, with a subsidiary laboratory at Slough. The work at these centres includes studies in entomology, mycology, and chemistry, and has been described recently by Munro (1933). For long-range research the Empire Marketing Board formerly provided some £4,000 per annum, and since its dissolution the Carnegie Corporation has contributed £2,000, and the Dominions and Colonies £1,600 per annum. For *ad hoc* industrial work an additional sum, which fluctuates from £2,000 to £3,000 per annum, is provided by the industries concerned.

This department has been of particular importance in reporting to the producing areas in Africa concerning the state in which goods arrive in England, and in directing attention to those pests which are most harmful in European warehouses though they may be relatively unimportant in Africa.

The government entomologists and mycologists in Africa have also paid much attention to these pests, especially in Southern Rhodesia, where the tobacco in storage suffers serious loss from insects, and in the Gold Coast and Nigeria, where stored cocoa is particularly susceptible.

One of the worst pests is the cocoa-moth *Ephestia elutella* (also *E. cautella*). This has been the subject of special research in the Gold Coast, where Cotterell (1934) has investigated its life history and means of control. A weevil (*Araecerus fasciculatus*), which is discussed by Cotterell in the same bulletin, has also been the cause

of serious loss to cocoa in the Gold Coast, but is fortunately incapable of withstanding the English climate. In Nigeria *Ephestia* appears to be a dangerous pest to cocoa only when the crop is kept in store for long periods, as in the financial depression of 1931. Research on the best methods of control is progressing there also.

The same moth attacks other stored products as well, notably tobacco and groundnuts. In the case of tobacco, the bumper crops of 1928 and 1929 in Rhodesia led to an overloading of the market so that large quantities were stored in British warehouses for unusually long periods. Great losses due to *Ephestia* and other insects led to agitation from city brokers which did much to stimulate research on its control. More recently attention has been drawn to this moth in other parts of Africa, owing to severe losses of groundnuts. From 1929 to 1933 exhaustive research was carried out in Professor Munro's department, and the reports by Munro and Thomson (1929) and Bovingdon (1933) show that the insect is particularly susceptible to humidity, so that control of warehouses may prove comparatively simple. Various large manufacturers of confectionery, notably Messrs. Cadbury, who obtain a large proportion of their cocoa from the Gold Coast, are now assisting in work on the control of humidity. The fumigation of warehouses with hydrocyanic and other gases is also a satisfactory means of control, but there is prejudice against it in the cocoa industry. It has been widely used for the control of other storage pests, however, and a fumigation apparatus is now established in Kenya for experiments in grain warehouses.

Attacks by *Ephestia* on groundnuts in store have been most pronounced in Senegal. Preventive methods have been the subject of study by Sagot and Bouffil (1935), working at the agricultural station of M'Bambey. They conclude that the pest can be controlled only by insecticides, of which Datura, which materially checks the multiplication of the insects without damaging the nuts, is most to be recommended.

In Southern Rhodesia *Ephestia* is only known on a few tobacco premises, but the beetle *Lasiodernia serricorne* F. is generally distributed and causes heavy losses. Both these pests are the subject of a report by Mossop (1932b). Hygienic conditions on premises used for handling and storing tobacco are enforced by legislation

under the Tobacco Pests Suppression Act, 1933, and a whole-time inspector is employed for this purpose.

In Southern Rhodesia, also, maize is subject to serious attack by the rice-weevil (*Calandra oryzae* L.) which appears to find both the climate of the colony and the flat white type of maize grown particularly favourable to its development. An entomologist has been detailed to carry out research of a fundamental type on the ecology of this pest and its relation to present methods of handling, storage, and exporting (Jack 1935b).

With reference to quite a different class of products, hides and skins, when stored in warm climates even for short periods, are very liable to attack from the skin beetle, *Dermestes vulpinus*. This pest was the cause of such loss, particularly in South Africa, that a special investigation was carried out by Smit (1934a) at Port Elizabeth into the means of protection. His conclusions show that salt and arsenite of soda, when properly applied, give complete protection, so that control of the pest is largely a matter of adequate attention in preparing the skins.

In all control of insects by fumigation and similar means, recent work on insect diapause (i.e. the period of life history when activity is temporarily suspended) is of the utmost importance, since insects are much more resistant to poisons at that time. Apart from the obvious diapause of pupation in the higher insects, it is now recognized that other less noticeable periods occur at various stages in the life history for reasons which are often obscure. This may necessitate much long-range research before control can be effective.

INSECTS AND TICKS IN RELATION TO DISEASE

The difficulties of medical and agricultural entomologists are essentially the same in so far as they depend on the circumstances and the people with which they have to deal. Most of the larger territories have entomologists attached to the medical departments, and some have also veterinary entomologists as well, but in others the same entomologists are responsible for agricultural, medical, and veterinary work.

The following brief account does not include references to the fundamental research which has revealed the causes of principal

diseases and related them to insect or arachnid vectors—such as the work of Sir Ronald Ross and after him Sir Malcolm Watson on malaria and mosquitoes, and of Sir Arnold Theiler and Lounsbury on the diseases of animals. It is restricted to work on the insect vectors of disease, and is intended to outline the recent advances in parts of Africa by reference to some of the more striking publications of the past fifteen years or so. Some questions connected with routine work on insect pests of man and animals, and the important surveys of rats and fleas in connection with plague, are mentioned in Chapters VIII and XVI. Apart from trypanosomiasis, the diseases which have received most attention in respect of entomological research are malaria, yellow fever, filariasis and relapsing fever in men, and piroplasmosis (east coast fever) and infestation by blowflies in animals.

Diseases of Man

By far the most important vectors of *malaria* are two species of mosquitoes, *Anopheles funestus* Giles and *Anopheles gambiae* Giles. Both are widely distributed with varying predominance, although *Anopheles gambiae* is mainly responsible for the transmission of malaria in East Africa and in Lagos. Research in recent years has been mainly directed to investigations on the incidence of the disease in various districts and to the control of the vectors themselves. The mosquitoes are most readily controlled in the larval stage, but effective control presupposes a fairly thorough knowledge of the distribution of a given vector in relation to the incidence of the disease, and of its bionomics, particularly its breeding habits. Thus, *Anopheles gambiae* breeds in pools exposed to sunshine and with little or no vegetation, whereas *Anopheles funestus* usually breeds in clear water where there is some degree of shade. In general, heavy shade makes conditions unsuitable for malaria carriers (De Meillon 1933). Such information must be supplemented by detailed study of the bionomics of the species, with the effect of local conditions upon them, and by statistical information on their population, as is pointed out by Davey and Gordon (1933) and by Anderson (1931). An ecological study of this type was made by Hancock (1934).

The correct application of suitable methods of sanitation con-

tributes towards the efficiency of control (Swellengrebel 1931). Filling up and draining waste land containing breeding-places, canalization, covering water-supplies, and improved sanitation have greatly reduced malaria in many places, such as Nigeria, where it was previously a serious danger. The work on Lagos Island and adjoining parts of the mainland may be mentioned as a good example. The expense involved in such operations is, however, heavy. Where water cannot be covered, it may sometimes be made unsuitable for breeding by other means. Thus oiling, for which Paris green has sometimes been found a satisfactory substitute, destroys larvae and prevents breeding in open water (Symes 1932). As a temporary measure the addition of cut grass or of vegetable refuse to waters has proved effective in Uganda. The effectiveness of such measures is increased when they are used in conjunction with an attack on the malarial organisms in the human host. This question is discussed in Chapter XVI.

A valuable contribution to the study of mosquitoes is a monograph on those of the Culicines of the Ethiopian region by Hopkins (1936). Other publications on this subject are numerous, especially those by medical entomologists in the several territories; among them the work of C. B. Symes of Kenya may be mentioned.

Much of the research on *Aëdes aegypti* L., the vector of *yellow fever*, has naturally been of the same type as that on the vectors of malaria. Investigations on breeding-places and the influence of climate and local conditions, piped water-supplies and effective sanitation have resembled those on *Anopheles*. The important work on the endemicity of yellow fever, in relation to the distribution of *Aëdes* and the possible spread of the disease, is discussed in Chapter XVI.

Another serious disease transmitted by mosquitoes is *filariasis*, of which the casual agents are *Filaria* spp., especially (*Wuchereria*) *bancrofti*. Apparently the relation between insects and the disease still calls for much research. Dissections of mosquitoes in search of micro-filariae in them suggest that *Anopheles gambiae* and *A. funestus* are probably the chief vectors in most places (Taylor 1930), although positive results have also been obtained with *A. pharoensis* Theo., *A. theileri* Edw., and, in Egypt, *Culex pipiens* L. (Khalil, Halawani, and Hilmy 1932).

PLATE IV

PRACTICAL MEASURES AGAINST INSECT PESTS

Above: A swamp near Lagos, Nigeria, is being filled with sand and earth to destroy the breeding ground of mosquitoes

Below: A strip of land adjoining a stream has been cleared of vegetation, and the debris burnt on the stumps, to destroy the breeding ground of tsetse flies; near Pong-Tamale, Northern Territories of the Gold Coast

Relapsing fever, which is widely distributed throughout Africa, is caused by *Spirochaeta* spp., which find a reservoir in mammalian hosts, especially rodents, and are frequently transmitted by lice and ticks. Thus in Morocco, *Spirochaeta duttoni* is transmitted to man by the tick *Ornithodorus erraticus* Lucas (Mathis, Durieux, and Advier 1934), and spirochaetes of the *Spirochaeta hispanica* group by lice of the genus *Linognathoides*. In Tunisia *Spirochaeta hispanica* is transmitted by *Ornithodorus erraticus*, and in Algeria by this tick and *Rhipicephalus sanguineus* Latr. (Nicolle, Laigret, and Sicard 1933 and Sergent 1933), while in French West Africa lice of the genus *Pediculus* are responsible for the transmission of *Spirochaeta recurrentis* (Mathis 1931). *Spirochaeta duttoni*, the causal agent of African relapsing fever, which occurs over the greater part of the continent is also regularly transmitted by *Ornithodorus moubata* Murr as shown by Martoglio (1931). In Uganda operations against the tick in temporary buildings have shown that fumigation is ineffective, but good results are obtained with a special spray, which can be used also against bed-bugs in permanent buildings without the necessity of sealing the rooms.

The biting-fly, *Simulium*, renders life unpleasant in parts of Uganda. In West Africa and almost certainly in Uganda it is known to carry a pathogenic nematode, *Onchocerca* (Gibbins 1933 and 1934, Strong 1935).

Diseases of Stock

Of the four major specific diseases of cattle which in the past have hindered the development of the stock industry in Africa, two, trypanosomiasis and east coast fever, are transmitted by Arthropoda.

East Coast fever, which is caused by specific infection with *Theileria parva*, a member of the piroplasm group, is widely distributed from Natal to the southern part of Italian Somaliland, and extends westward into the Belgian Congo, where an outbreak has been described recently by Schwetz (1932). The main vector of east coast fever throughout this area is the tick, *Rhipicephalus appendiculatus* Neumann. The life cycle of *T. parva* has been studied at Kabete in Kenya, using *R. appendiculatus* as vector (Cowdry and Ham 1932 and Cowdry and Danks 1933). The account of the

development of the parasite in both intermediary and definitive hosts is a useful contribution to knowledge of the life cycle of piroplasms, a subject which, in recent years, has received a good deal of attention in various parts of the world. Earlier work in South Africa by Theiler and Lounsbury has shown that in addition to *R. appendiculatus* certain other African species of the genus *Rhipicephalus* are capable of acting as experimental vectors of east coast fever. At the present time there is in progress at Kabete a systematic revision of the transmission of this disease. Different species of ticks are being examined with regard to their ability to transmit pure infections and the characters of the transmitted disease are being observed for signs of difference in the disease as transmitted by different hosts; already a new experimental transmitter has been discovered in *Hyalomma aegyptisum impressum.* In 1929, an entomologist was engaged to carry out a tick survey in Kenya in order to ascertain the exact distribution of *R. appendiculatus*, and to investigate the ecological factors responsible for it. Already the distribution of tick species has been plotted (Lewis 1931–4) and climatic conditions likely to affect this distribution are being studied in the laboratory. Periodic collections of ticks have been submitted to Kabete also from Tanganyika and the Gold Coast. It is of interest to note that although east coast fever is unknown on the west coast of Africa, *R. appendiculatus* has appeared in collections of ticks from Pong-Tamale in the Gold Coast.

Theileria parva, the parasite of east coast fever, does not pass from adult to larval stage through the egg of the tick; on the other hand, in the *Babesia* group, which includes the parasites of redwater of cattle, biliary fever of horses, and tick fever of dogs, hereditary transmission is effected. The main vectors of the latter group of piroplasms belong to the genus *Boophilus*, all of which are continuous feeders; that is to say, they do not drop to the ground to moult from larva to nymph and nymph to adult, as do members of the genus *Rhipicephalus*, but remain on the same host during all three instars; and it is, therefore, necessary that the protozoan parasite should pass through the egg of the tick in order to ensure its transference to a fresh host.

Two other *Theileria* species, *T. annulata* and *T. dispar*, cause serious diseases of cattle, the former in Asia and the Mediterranean

basin and the latter in Algeria. *T. dispar* is transmitted by *Hyalomma mauritanicum* Senevet, and it is of interest to note that the survival of infected nymphs, which hibernate during the winter months, is largely responsible for the carrying-over of the disease from year to year.

In East Africa, it has been shown by Montgomery (1917) and Daubney and Hudson (1931a) that Nairobi sheep disease, a highly fatal virus disease of sheep and goats, is mainly transmitted by *R. appendiculatus*, the common vector of east coast fever, but that in certain areas where *R. appendiculatus* does not occur, the virus may also be transmitted by *Amblyomma variegatum* (Daubney and Hudson 1931a and 1934).

Another disease of cattle, sheep, and goats which can occasion severe mortality is heart-water. The causal parasite of this disease, *Rickettsia ruminantium*, was discovered by Cowdry (1925) working at Onderstepoort. In South Africa heart-water is transmitted by *Amblyomma hebraeum* (Lounsbury 1902a and b), and it is likely that this tick continues to serve as a vector for heart-water up to the northern limit of its distribution in East Africa, which is probably somewhere in the south of Tanganyika. In Kenya it has been shown that heart-water is naturally transmitted by *A. variegatum*, which is widely distributed throughout the Colony (Daubney 1930). It is possible that another member of the genus *Amblyomma* may, in certain areas, also act as a vector of heart-water.

The only satisfactory means of controlling the tick-borne protozoan diseases is dipping or hand-dressing of stock, coupled with fencing of pastures to prevent trespass of undipped cattle. The manner in which these measures affect the ticks is mentioned in Chapter XIV.

Myiasis or Screw-worm of cattle, sheep, horses, and dogs is common in many parts of Africa. It is due to infection by blowflies, of which *Chrysomyia bezziania* Villen is the commonest in Rhodesia, and is widely distributed in Kenya, although *Lucilia cuprina* Wied. also causes myiasis in sheep in both territories, as shown by Smit (1931) and Lewis (1933). A good deal of valuable research has been done on various dressings for large open wounds and on substances to be applied after larval and egg-masses have been removed from infected animals. The necessity of ensuring

that all larvae removed from wounds are effectively destroyed has been demonstrated, especially in Southern Rhodesia by Lawrence and Cuthbertson (1934). This is a precaution which is apt to be neglected, with the result that large numbers of adult flies are bred unnecessarily, and the mustering pens tend to become centres of infestation.

There are several important non-contagious virus diseases of stock in Africa. Blue-tongue of sheep and horse-sickness have much the same distribution in South Africa and Kenya, the two countries where they have been investigated. At Onderstepoort extensive observations have been made on the capacity of these two viruses to survive in mosquitoes. In two out of thirty-five experiments the virus of horse-sickness was shown to have survived in *Aëdes caballus* and *A. lineatopennis*, but the results of the whole series of experiments forced the workers to the conclusion that *Aëdes* species are very probably not the natural transmitters of horse-sickness (Nieschulz, Bedford, and du Toit 1934a). In the experiments with blue-tongue virus, *A. lineatopennis* was twice shown to have retained virus from fifteen to nineteen days, but the same workers (1934b) conclude that the problem of natural transmission has not been solved.

A virus disease of sheep, cattle, and man, which has resemblances to both dengue and yellow fever, was discovered in 1930 in Kenya and named rift valley fever by Daubney and Hudson (1931b). Its existence has recently been suspected in the French West African territories. It has been shown by Findlay and Daubney (1931) that rift valley fever is immunologically distinct from yellow fever and dengue, and that mosquitoes of the genus *Mansonia* are experimental vectors (Daubney and Hudson 1933). There is evidence also that one of these species, *Mansonia fuscopennata* (Theobald), may acquire infection during the course of a natural outbreak.

CHAPTER XI

AGRICULTURE—GENERAL

INTRODUCTION

SINCE Africa must always be primarily an agricultural country, the practical value of agricultural science hardly requires comment, but certain introductory remarks are necessary on the various branches of African agriculture and on the influences which are impeding progress. The subject is so vast that some division is necessary as a basis for the discussion of present tendencies in different parts of the continent and the results of research. At first sight the division of plant from animal industry, the latter to include veterinary studies, would seem practicable, but methods of cultivation are so often dependent on stock, and mixed farming is coming to be so widely regarded in many places as the ideal of agriculture in Africa, that it is almost impossible to separate these subjects.

More satisfactory is the division into three categories: Firstly, native subsistence agriculture, including both cultivation of the soil and animal husbandry, is important all over the continent. This subject has been relatively less thoroughly studied by scientific research than the other two. Secondly, native agriculture for export, especially the growing of cash crops such as cocoa, coffee, cotton, and groundnuts, is increasing in importance every year and will probably continue to do so, especially if the sale of animal products can be developed side by side with that of crops. Thirdly, the agricultural activities of non-native peoples, especially Europeans, are of importance mainly in the southern and some of the eastern parts of the continent.

Even the distinction between European and native cash crops is difficult to maintain, for there is a constant and increasing inva-

sion by native cultivators of what at first glance appears to be peculiarly non-native agriculture. Since both native and non-native are coming to use the same elements in production, the real division probably lies between those methods which do and do not involve the investment of capital.

Accordingly it has been found impossible to divide the subject directly in accordance with the categories mentioned, but an attempt has been made to treat native and European agriculture separately. After an account of the organizations for agricultural administration and research there follows a chapter on crop plants, which discusses both native and non-native agriculture and summarizes some recent advances in the fields of plant breeding and methods of cultivation. General questions of plant industry are treated in two sections of Chapter XIII, devoted respectively to the practice of native and non-native peoples. Most of the problems of animal industry and animal disease are reserved for Chapter XIV, but animal husbandry of necessity enters into a discussion of mixed farming in Chapter XIII. The problem of the deterioration and erosion of soils has already been discussed in general terms in Chapter V, but it is of such great importance to African agriculture that it is also mentioned here, especially in the sections devoted to native agricultural practices.

To the native peoples agriculture is an essential part of tribal life and innovations are resisted through attachment to customary methods and sometimes also through the influence of religious and magical belief. In the past the enforcement of radical changes in native methods has been advocated, but in recent years native agricultural practice has been regarded as worthy of respect. It is now coming to be realized that drastic methods rarely achieve their object, and that improvements are more likely to be attained by gradual development from existing methods. The first step is to understand these methods and their reasons, just as has been done in the study of agricultural science in Europe during the past fifty years. Native methods are then submitted to scientific analysis and experiment, and improvements, when discovered, are encouraged through the medium of demonstration farms and other forms of education. This procedure may not be applicable to exotic crops such as cotton, coffee, or cacao, which are new to

the native peoples. In such cases, the native has to be taught methods which are likely to be successful in his hands from the beginning.

In applying new or improved methods among native agriculturists, a major question is whether or not some form of compulsion is justified or even effective. As a rule, in British territories, every effort is made to avoid compulsion, but there are certain cases where it appears to be justified. For example, where a new crop of known value and suitability is to be introduced in an area, some compulsion in the initial stages may be the only way of demonstrating to the farmers the advantages which they themselves can derive from its cultivation. Again in the control of certain pests and diseases, measures may have to be enforced on all farmers, irrespective of race, in order to protect the careful farmer from his neighbour's neglect. Such cases are covered by agricultural pests and diseases ordinances. In certain colonies, moreover, compulsory measures against soil erosion, made applicable to natives, may have resulted in a greater advance in the lay-out of native than of non-native farms. In the opinion of some authorities the only way to make real advance in some forms of indigenous agriculture is by compulsion on a large scale, as in the compulsory system employed with success in the Congo (see later), and the proposed compulsory culling of stock to reduce over-grazing in East Africa. If it is possible to generalize about so complicated a question, it may be claimed that at least in British territories it is the aim to improve native methods by education and only to employ compulsion where all else has failed. In some non-British territories direct compulsion is more often used, with the consequence that results are produced more rapidly and more cheaply, but perhaps they are not so satisfactory in the long run.

It is a simple truth, realized by all concerned, that the principal factor retarding native agricultural improvement is a lack of balanced knowledge concerning conditions of native life. Modern anthropology helps to fill this gap, but for the practical advances in view recent work in this field does not appear always to lay sufficient stress on the material background of man's environment. There is general agreement as to the importance of agricultural advance among Africans, as a basis for general improvements in

the standard of living; but before native agriculture is improved we must have a sound knowledge of existing conditions.

Such knowledge comes perhaps into the province of human geography rather than of either anthropology or agriculture. Information is being obtained from certain areas by special inquiries, such as the agricultural survey of Nyasaland, the ecological survey of Northern Rhodesia, the combined agricultural, geological and other studies in Uganda, and in Tanganyika surveys of areas such as Ukara Island and Musoma district, and Mr. Gillman's recent studies of population and water-supplies, each of which is noticed in other parts of this volume. In addition, however, a great mass of valuable data is gathered by individual officers in administrative, agricultural, and other departments in the course of their routine duties. Much of this information is lost through the absence of any central organization in which it could be collected and disseminated. It was in the hope of filling this lack that a centralized body, the Committee of the British Association on the Human Geography of Intertropical Africa, was formed in 1926 at the Oxford Meeting of the British Association. The committee has Professor P. M. Roxby as Chairman and Professor A. G. Ogilvie as Secretary. A list of questions, together with two model essays on the relation of African tribes to their environment (those of P. L. Martrou on the Fang and R. U. Sayce on the Basuto), was circulated in pamphlet form to the governments of British colonial Africa.

In Northern Rhodesia the administration invited all officials to reply to the questionnaire, and thirty reports have been contributed, covering every district except two. Several of these reports have been edited and published in the pages of *Geography*, and Professor Ogilvie (1934) devoted his presidential address to the Geographical Section of the British Association to the subject. He pointed out that in the absence of accurate maps showing topography, geology, soils, and vegetation, the results cannot attain proper significance. Accordingly guesswork must play an important part in relating the distribution, habits, and particularly the agriculture of tribes to the physical environment. The physical conditions of Northern Rhodesia are similar in many respects to those of the adjoining region of Katanga, so that the fine series of

Katanga maps (mentioned in other chapters) has proved of value in interpreting the reports. The committee proposes later to combine the reports received in a volume on the human geography of Northern Rhodesia. This should provide a basis for future work, and if the procedure can be extended to other parts of Africa and the results are made available in convenient form, the direction of native development in agriculture and in other subjects should be facilitated.

In connection with European farming, scientific advance has naturally gone further in South Africa than elsewhere. It has been realized only in recent years by Governments and the farmers themselves that South Africa is in the main a country for animal industry rather than for grain. H. D. Leppan, Professor of Agriculture at Pretoria University, has developed this opinion in two recent books (1931 and 1936), pointing out that more than 80 per cent of the area of South Africa can never be used except for grazing; that in a country where rains are apt to fail, animals can be moved under necessity, but crops cannot. He claims that the export of grain, especially maize, implies that some other country's soil is being manured through the medium of domestic animals, a policy which can hardly be economic in a country, such as South Africa, where the soil is predominantly poor. On the other hand, animal industry, if properly controlled, can help to rectify the lack of soil fertility.

The great problem for an agricultural country is stability in production with a surplus for foreign markets. It appears that such agricultural stability can only be attained in South Africa by animal husbandry, except in the comparatively limited areas of steady rainfall well distributed through the seasons where crops, especially fruit, are highly suitable, or in areas where irrigation has been introduced.

This theme has been developed further in many recent publications from South Africa. For instance at the 1934 meetings of the South African Association for the Advancement of Science, Dr. A. L. du Toit, as president of the association, gave a lucid summary of agriculture and mining in South Africa (1934), much of it based on the conclusion that 'as so many authorities have long pointed out, South Africa is in the main a pastoral and not

an arable country'. T. D. Hall (1934) in his presidential address (on pastures) to section C of the association, pointed out that more than thirty years ago several experts who were at work on stock range investigations, were diverted to arable problems. Dr. Burtt Davy, for instance, was gathering data on the stock-carrying capacity of land and indigenous grasses 'when he was told to devote his time to the maize industry which was considered of greater importance—a decision that has cost South Africa a great deal'.

In certain settled areas in East Africa the same principle may apply. The country now devoted to coffee, tea, and sisal is on the whole unsuited to stock raising, but land now used for maize, and perhaps the wheat lands also, would probably be more valuable for mixed farming. The problem is, of course, largely an economic one, dependent on demands of the moment and the capacity of each area to produce exports in competition with the world's cheapest producers.

In native agriculture the relative merits of land for crops or stock are equally if not more important. Here agricultural developments are closely bound up with measures for the control of disease. It is known by the natives themselves that many insect-borne diseases of plants, animals and man may be avoided or reduced by fairly close settlement, leading even to the verge of soil erosion. It is not yet known to them, however, that by their own efforts a reasonable standard of fertility can be maintained together with close settlement, through the adoption of methods such as mixed farming.

When attempting to foresee Africa's future the example of other countries in warm latitudes may well be of assistance. When land is available in large blocks the first settlers are generally stock men like the early Australian farmers, the ranchers of the United States and the farmers in South Africa. Even the earliest settlers in Kenya went there in the hope of its becoming a stock country. Later, as land values rise, pastoral holdings are broken up and a cultivation phase sets in, to be succeeded in its turn by mixed farming. Such a sequence of events has taken place in many parts of Australia and America. At the present time in parts of the United States of America it appears that too much concentration of crops has led to serious soil exhaustion and erosion, so that the recent commission

on national resources has pressed for the laying down to pasture of large areas in order to retain a permanent cover of vegetation. The Argentine has had a somewhat different history: grain crops paid for breaking up the country in the initial stages, and after a time much of the cultivated land was laid down to pasture and cattle-raising took the place of wheat-growing.

Generalizations such as these are perhaps rash because there are so many factors which influence any change in agricultural activity. Moreover, the traditions of the original immigrants in a country doubtless have far-reaching effects: Australia, North America, and South Africa were settled mainly by the Anglo-Saxon races, who have for centuries had the tradition of stock behind them. In the case of the Latin races, whose outlook in farming is largely arable, the tendency is to develop cultivation rather than stock. In the French colonies of north Africa, for example, the type of agriculture developed by settlers is entirely arable, and the only stock raised there are those belonging to the indigenous peoples of the country. In South America also, the initial agricultural developments due to Latin immigrants were all in the direction of growing crops and to a considerable extent remain so, for the Argentine is still the world's greatest exporter of maize in spite of the development of stock referred to above.

In tropical Africa the early hopes of stock raising gave place to a concentration on agriculture because reservoirs of stock diseases existed everywhere in native cattle and game animals. Even now the relationship of game and stock with regard to disease is extremely obscure, but many of the worst troubles are controllable. High-yielding races of stock, immune from disease, are being bred, and game animals are retreating from settled areas into sanctuaries.

It may be concluded from these arguments that, as years proceed and the results of pasture research become generally applicable, many of the settled areas now under crops may be used for mixed farming. Pastoral farming alone is unlikely ever to usurp wide areas in the African highlands, because additional feed will be necessary for parts of the year, and this cannot be provided unless it is grown locally.

ORGANIZATION

BRITISH

There are first to be considered central institutions in Great Britain which deal with the whole British Empire.

The *Imperial Institute* at South Kensington has important relations with the African territories, whether Dominions or Colonies, in both the intelligence and research sides of its work. The Institute's Advisory Council for Plant and Animal Products, under the chairmanship of Sir F. A. Stockdale, serves in an advisory way as a link between the producer and industrial firms in this country. The consultative committees on special subjects,under the Council, therefore include business men as well as scientists. The subjects dealt with are overseas timber, sericulture, vegetable fibres, oils and oilseeds, essential oils, gums and resins, tanning materials, hides and skins, and insecticide materials of vegetable origin. Many important results of research in these subjects are published in the Bulletin of the Imperial Institute.

The organization of the *Imperial Agricultural Bureaux* is more recent than that of the Imperial Institute and serves a different purpose. It resulted from the Imperial Agricultural Research Conference of 1927, when research workers from all over the Empire pointed out the difficulty of keeping abreast of the literature published in their various special branches of agriculture. The bureaux function as clearing-houses for information, and do not undertake research work, though each is located at a centre well known for researches in the branch of agricultural science with which it deals. The bureaux operate under an Executive Council consisting of representatives of the British Isles, Dominions, and Colonies with Sir David Chadwick as Secretary (I.A.B. 1938).

The list of Bureaux in 1937 was as follows:

Imperial Bureau of	*Director*	*Deputy Director or Chief Officer in direct charge of Bureau*
SOIL SCIENCE:		
Rothamsted Experimental Station, Harpenden, Herts.	Sir E. J. Russell, F.R.S.	G. V. Jacks

Imperial Bureau of	*Director*	*Deputy Director or Chief Officer in direct charge of Bureau*
ANIMAL HEALTH: Veterinary Research Laboratory, Weybridge, Surrey	Dr. W. Horner Andrews	W. A. Pool
ANIMAL NUTRITION: Rowett Research Institute, Aberdeen	Sir J. B. Orr, F.R.S.	Dr. F. C. Kelly
PLANT GENETICS: (for crops other than herbage) Plant Breeding Institute, School of Agriculture, Cambridge	Professor F. L. Engledow, C.M.G.	Dr. P. S. Hudson
PLANT GENETICS: (herbage plants) Welsh Plant Breeding Station, Agricultural Buildings, Aberystwyth	Professor R. G. Stapledon	Dr. R. O. Whyte
FRUIT PRODUCTION: East Malling Research Station, Kent	Dr. R. G. Hatton	D. Akenhead
ANIMAL GENETICS: Institute of Animal Genetics, University of Edinburgh	Professor F. A. E. Crew	Vacant
AGRICULTURAL PARASITOLOGY: Institute of Agricultural Parasitology, St. Albans, Herts.	Professor R. T. Leiper, F.R.S.	A. E. Fountain

In addition to these, the Imperial Institute of Entomology, under Sir Guy Marshall, with headquarters at the British Museum of Natural History, and the Imperial Mycological Institute, under Mr. S. F. Ashby, at Kew, of which the inception predated that of the other bureaux, have come under the Executive Council with effect from 1934. They differ from the Agricultural Bureaux in that both undertake works of identification, which entail laboratory accommodation for their culture. The Bureau of Hygiene and Tropical Diseases, also formed prior to 1927, continues under its own managing committee (*see* Chapter XV).

The object of each bureau is to establish and maintain direct touch with research workers and to be of service to them by bring-

ing to their notice work done in their subject elsewhere in the world, by answering inquiries, by supplying translation of papers, and by placing research workers in touch with each other. This object is brought about principally through the medium of the following abstracting journals, which summarize important work published in every language: *Soils and Fertilizers*, *The Veterinary Bulletin*, *Nutrition Abstracts and Reviews*, *Plant Breeding Abstracts*, *Herbage Abstracts* and *Herbage Reviews*, *Horticultural Abstracts*, *Animal Breeding Abstracts*, *Helminthological Abstracts*, the *Review of Applied Entomology* and the *Review of Applied Mycology*. In addition to the abstracting journals, most of the bureaux also publish from time to time special monographs and memoranda reviewing specific problems.

The *Agricultural Research Council*, with its several committees on special subjects, is responsible for the correlation of results from many researches in Great Britain, and has funds for annual allocation to special pieces of work under its own control, or for the extension of work at other institutions. The report for the period 1931 to 1933, being the first two years of the Council's activities, issued in 1934, includes admirable summaries of recent advances in the several agricultural subjects and describes work which is being undertaken at research institutes in Great Britain. Although the Council operates only within the United Kingdom, many of its conclusions have applications in the African field.

Research on food preservation in Great Britain is carried out by the Food Investigation Board of the Department of Scientific and Industrial Research. There are three laboratories financed mainly by the D.S.I.R., and devoted to the subject: the Low Temperature Research Station at Cambridge for work on fruit and meat, where research has been developed by the late Sir William Hardy; the Ditton Laboratory at East Malling which was opened in 1931 for work on fruit; and the Torry Research Station at Aberdeen for work on the preservation of fish. Of these the Cambridge laboratory is the oldest and is the only one at present which has directly studied African problems. In addition, the Department of Entomology at the Imperial College of Science and Technology in London, under Professor Munro, has been much concerned with insect pests of stored products (*see* Chapter X).

In the *Union of South Africa* all Government agricultural activities are combined under the Department of Agriculture and Forestry. The agricultural side of the department is divided into three divisions of Chemistry, of Plant Industry and of Veterinary Services. Some of the work of these divisions has been mentioned in earlier chapters, and the establishment of the Division of Chemistry is given in Chapter V.

The Division of Plant Industry, under Dr. I. B. Pole-Evans, with a total staff of a hundred and nine in 1937, is centred at Pretoria. Now that South Africa is being recognized to be better suited for stock raising than agriculture, much stress is being laid on pasture investigations, and a large experimental farm for this work is established at Pretoria. Among stations for crop investigation may be mentioned the horticultural station at Nelspruit (chiefly for citrus), Buffelspoort citrus canker station in the Transvaal, the pineapple station at Bathurst, C.P., and the viticultural station at Paarl, C.P. Other stations under the Division of Plant Industry are at the Schools of Agriculture at Grootfontein, Potchefstroom, Glen (O.F.S.), and Cedara (Natal). Low temperature research and fruit inspection, which have their headquarters at Capetown, likewise fall under the direction of the division. The Sugar Association has an experimental station at Mount Edgecombe, near Durban, where research on sugar cane is being done under Mr. Dodge. Agricultural organization in the winter rainfall area of the Cape Province is in the hands of the Stellenbosch-Elsenburg College of Agriculture of the University of Stellenbosch, which now belongs to the civil service. Most of the agricultural training and a good deal of research in South Africa is carried out by the departments of agriculture in this and other universities.

The Faculty of Agriculture at Pretoria University which maintains a large experimental station, is not under the direct control of the Department of Agriculture and Forestry, as are the above, but receives financial support from it. The University of the Witwatersrand has conducted work on veld and pasture investigations since 1932, and has established a special station for this purpose at Frankenvald, near Johannesburg, where 1,000 acres are available for experiments. Research is also carried out by several companies which have farms and laboratories for the pur-

pose: African Explosives and Industries, Ltd. have done much work on cereals and insecticides in addition to that on pastures mentioned in Chapter VI, and the research work of the Zebedelia Citrus Estates may also be mentioned.

On the side of animal industry, the Division of Veterinary Services, under Dr. P. J. du Toit, has its centre at the Onderstepoort Laboratory near Pretoria, one of the best equipped veterinary laboratories in the Empire. This was established in 1902 and grew to its present eminence largely through the work of the late Sir Arnold Theiler. Recognition of the valuable work done in controlling the numerous stock diseases which spread throughout South Africa after the Boer War has attracted liberal endowments to this institution, and at present the annual allocation stands at over £100,000 a year. The work of the division is now being enlarged by the addition of a cold storage section which is being built at Onderstepoort for studies in the preservation of meat, eggs, and dairy produce. The research and travelling branches of the veterinary service, which were formerly under separate direction, have been amalgamated for purposes of closer co-operation. The present staff of the division numbers about two hundred veterinary workers, of whom some fifty-five are devoted to technical research at Onderstepoort. The training of veterinarians is also carried out at the laboratory.

In connexion with the industry of fruit and other perishable foods the Department of Agriculture and Forestry maintains at Capetown a Low Temperature Research Laboratory under Mr. Rees Davies. This was established in 1926 and has an Entomological Laboratory attached for the study of insect pests of dried fruit, beans, grain, etc. It is now being extended by the addition of a Food Products Research Laboratory for work on the preservation of food by canning, desiccation, etc. Refrigeration, though suitable for the export trade, cannot be used adequately for retail distribution to sparsely populated districts, and hence canning and desiccation are generally more applicable to the internal markets of Africa. The low temperature research laboratory provides facilities for the fisheries division to investigate the preservation and transport of fish. In addition to providing research facilities, the department of agriculture and forestry exercises control over

factories and cold storages which handle perishable produce, by a system of inspection and licensing. It also controls all technical aspects relating to rail transport, pre-cooling, and ocean transport of perishable produce intended for export.

In addition to the organizations outlined above, the Native Affairs Department of the Union Government has a large and well-qualified European staff and approximately two hundred and fifty native agricultural officers, who have been trained at agricultural institutions such as Fort Cox and Fort Hare University College.[1] Research in the ordinary sense scarcely comes within the purview of this department, but its extension work among the native population is of the utmost importance. Basutoland has some twenty-five of these trained native officers and others operate in the native territories of the Union.

Among publications on the subject in South Africa, *Farming in South Africa* is an official monthly journal published by the department of agriculture and forestry. It contains articles and short reports on research work which is of practical value to farmers, and the December number each year contains the annual report of the Secretary for Agriculture on the year's progress and activities. Bulletins, both scientific and with practical advice to farmers, are published as required by the several divisions of the department. In addition, the division of plant industry publishes *Memoirs of the Botanical Survey of South Africa*, the *Bothalia* series, and *Entomological Memoirs*. The results of work at the Onderstepoort Laboratory have, since 1933, been published quarterly by the division of veterinary services in the *Onderstepoort Journal*. Earlier results are contained in a series of eighteen reports of the Director.

In *Southern Rhodesia*, centred in Salisbury, an extensive Department of Agriculture, a strongly staffed Veterinary Department, and a Department of Veterinary Research are embraced within the Ministerial Division of Agriculture and Lands. The department of agriculture, whose work is devoted primarily to the problems of European farmers and ranchers, is subdivided into branches specializing on the development of water-supplies, on water and soil conservation, animal and field husbandry, including tobacco and cotton, dairying, poultry, forestry, agricultural

[1] See *A Survey of Africa*, Chapter xviii.

marketing, entomology, plant pathology, meteorology and chemistry. The European staff of the three departments numbers 257, of whom twenty-five are specialist officers engaged in administrative or research duties. Research stations are maintained as follows: two stations, each of about one hundred acres in area, in close proximity to Salisbury. On one, known as the Salisbury Experimental Station, the chemical, entomological, and plant pathological laboratories of the department are situated. This station concentrates on experimental work with grain and legume crops, potatoes, and pasture grasses, and on manurial, fertilizer, and green manuring experiments, and new crop introductions. The second, the Hillside Station, is devoted to plant breeding, mainly with wheat, and to trypanosomiasis research. Sixty miles north of Salisbury is the Trelawny Tobacco Research Station of 500 acres, with a research staff of eight, including a plant breeder, a chemist, a biologist, a plant pathologist, and a physiologist. Stations concentrating on pasture research are situated at Matopo, Marandellas, and Rusape, the first-named forming part of the Rhodes Matopo Estate and Experiment Farm, some twenty-seven miles from Bulawayo. The experiment farm is mainly concerned with problems of cattle and pig breeding and animal nutrition, and crop production under Matabeleland conditions. The British South Africa Company maintains the Mazoe Citrus Research Station (60 acres), with a staff of six specialists. The *Southern Rhodesia Agricultural Journal*, published monthly, records the investigational work and other activities of the department and has, besides that within the colony, a considerable circulation amongst farmers in adjoining territories. In addition a large number of departmental bulletins have been published, and the annual report of the department of agriculture and lands, as presented to the Legislative Assembly, is published each year in March or April.

The *Anglo-Egyptian Sudan*, though not strictly within the scope of this study, is important for comparison. Its present large agricultural organization was formerly divided into two: the Department of Agriculture and Forests, with headquarters at Khartoum, and the Agricultural Research Service centred at the Medani Laboratory. These two branches were combined in 1935. The research service has two experimental stations: the Gezira re-

search farm with laboratories at Medani, where there are some thirteen scientists, and the Shambat central research farm. Nearly all work is concentrated on cotton and the crops which are grown in rotation with it. Other stations in the territory are maintained by the department of agriculture and forests, and in particular arrangements are going forward for developing parts of the Southern Sudan, where it appears that crops can be grown without irrigation.

In all *territories under the auspices of the Colonial Office*, agricultural policy is formulated in the territories themselves, but approval is sought from the Secretary of State in the case of any major change involved. As an advisory body in England to the Secretary of State there is the *Colonial Advisory Council of Agriculture and Animal Health*, which consists of scientific experts under the chairmanship of the Parliamentary Under-Secretary of State, with Sir F. A. Stockdale, Agricultural Adviser to the Secretary of State, as vice-chairman.

The organization of Government departments varies in different territories. In Kenya the Department of Agriculture has a central directorate at Nairobi, with separate divisions for plant industry and animal industry. In most of the territories, however, there are distinct veterinary departments, or departments of animal health, which have been developed in Africa, owing to the special problems created by stock disease. In some cases, as in Tanganyika and the Gold Coast, the veterinary departments are concerned with questions of animal husbandry, including breeding and feeding, in addition to those of disease. More commonly, however, the departments of agriculture have taken over much of the work in animal husbandry, though maintaining liaison with the veterinarians; this is the case especially in Nigeria, where mixed farming is being developed and the agricultural department has its own stock farm and staff of experts in animal husbandry, and in Uganda. Territories which have no separate department for veterinary work are Sierra Leone, where animal husbandry is relatively unimportant, the Gambia and Somaliland, each of which has a small combined department. The High Commission territories of Basutoland and Bechuanaland likewise have small agricultural departments which deal with both aspects.

Although the responsibility for research lies entirely with the departments of agriculture and animal health, the application of the results of research in improving native agriculture often comes into the domain of other departments. As a rule field agricultural officers demonstrate methods of improved cultivation, but they can do little without full co-operation from administrative officers, who must often take the lead themselves, so that some knowledge of agriculture is coming to be of great importance to administrative officers. In many territories it is realized that the work of putting results of research into practice among native peoples has grown too large to be undertaken by the agricultural and administrative officers, and therefore subordinate staffs of trained African agriculturalists are being built up. This question of subordinate staff is perhaps of more importance in agriculture than in any other subject: it is discussed in *An African Survey*, Chapter XIII.

The British staff of the agricultural departments is recruited from persons who already have university degrees. After selection they spend a year at the Cambridge School of Agriculture, and then go to the Imperial College of Tropical Agriculture at Trinidad for a second year before taking up their appointments. The Cambridge and Trinidad years have been arranged to constitute a continuous two years' course for the various kinds of specialists and field officers required. Similar arrangements exist in the case of probationers for the colonial veterinary services. In view of the heavy expenditure entailed by such training and the fact that every new agricultural officer absorbed into the departments has received training to equip him for research, there is a certain anomaly in the amount of time that they are required to devote to duties for which such training is scarcely required, and which in other territories, notably the French colonies, is entrusted to auxiliary African staff.

The *East African Agricultural Research Station at Amani*, as one of the projected chain of central research stations in the tropical Empire, is designed to serve all the East African colonies in the investigation of problems which have a general rather than a local application. It is devoted entirely to long-term research, but at present its activities are limited by a lack of funds which is reflected in the small number of the personnel. In its comparatively short exis-

tence Amani has produced work of the first importance which is mentioned in various parts of this report. Annual reports have been published since 1928, and results of the research of individual workers have been published in various scientific journals. Some of these have been reprinted as *Amani Memoirs*.

Technical Research Staff (1)

	Plant Industry	*Animal Industry*
Union of South Africa (2) ..	119	56
Southern Rhodesia (3)	23	1
Northern Rhodesia (4)	4	—
Empire Cotton Growing Corporation.	1	
Nyasaland	5	—
Empire Cotton Growing Corporation.	1	
Tanganyika (5)	12	5
Kenya	16	6
Uganda (6)	10	—
Zanzibar	6	—
Nigeria (7)	44	5
Gold Coast	21	—
Sierra Leone	4	—
Gambia	1	—
Somaliland	1	
Anglo-Egyptian Sudan (8) ..	16	—

(1) As listed in I.A.B. handbook (1938).
(2) Plant and Animal Industry, exclusive of Schools of Agriculture.
(3) Includes Trelawny Tobacco Station staff of seven, and officer at Matopo School.
(4) Includes Ecological Survey.
(5) Excludes Department of Tsetse Research, and Amani.
(6) Includes four entomologists.
(7) Excludes Tsetse Investigation staff of two.
(8) Includes four entomologists, excludes Chemical and Soil Science sections.

In order to give some indication of the equipment of the territories for agricultural research the above table of staff engaged in research has been compiled from the list of agricultural research workers in the British Empire, produced by the Imperial Agricultural Bureaux (1938). It should be realized, however, that it is impossible to make a strict division into research and administra-

tion, since every scientifically trained member of an agricultural department is potentially a research worker: those stationed as district agricultural officers, among other duties, investigate native custom and practice, a work which must come under the designation of research. The table includes only those officers engaged to investigate some special branch of agricultural science, such as chemistry, botany, or entomology.

In *Northern Rhodesia* the central research station of the Departments of Agriculture and of Animal Health at Mazabuka has concentrated during the past few years on pasture work and cover crops, with maize as another important subject, but recent economy measures have severely limited this work. Veterinary research at Mazabuka has also been impeded by lack of funds, so that little pure research could be undertaken. The veterinary research officer has, however, continued his studies of helminthology. Stations at Abercorn for coffee and native crops, and at Fort Jameson for tobacco and native crops, have recently been opened by the agricultural department, but their work has similarly been handicapped, although in 1936 the appointment of an additional officer made it possible to open another of these stations at Pemba. The Ecological Survey of Northern Rhodesia with staff of a plant ecologist and an agricultural officer, which has been referred to in Chapters V and VI, has done extremely valuable work and is demonstrating the importance of native agriculture as an ecological factor. In addition to annual reports, the department published annual bulletins with articles on the results of research from 1931 to 1933 when they were suspended as a measure of economy.

In *Nyasaland* the headquarters of the Agricultural and Veterinary departments are at Zomba, where new laboratories for the agricultural department are just being completed and an experimental area of about sixty acres is under cultivation. Research on tea production is a special object of the experimental station at Mlanje, which is in charge of the plant pathologist. There are experimental stations for cotton, at Port Herald, and at Makwapala near Zomba, the latter recently taken over from the Empire Cotton Growing Corporation, which maintains a station at Domira Bay. Special attention is given to tobacco, and a Native Tobacco Board, which, in 1936, employed seventeen Europeans, supervises and distributes

seed to native growers on unalienated Crown land, and finances experimental stations at Zomba and Lilongwe. The agricultural department has started work on native food plants. Annual reports are issued and since 1932, a series of small bulletins each on a special branch of agriculture in the territory, has been published.

In *Tanganyika* the headquarters of the Agricultural Department are at Morogoro. There are ten principal stations for arable agriculture, and about sixty substations, the latter mostly under native authority. Many of the stations are small with an annual allocation of a few hundred pounds. A notable experimental station is at Lyamungu near Moshi, for agronomic and long-range research on coffee, including breeding, which had been started previously only at Amani. The Lyamungu station is under the control of a coffee advisory board consisting of four official and seven unofficial members. A sisal advisory board has also been established and a special research station has been set up at Mlingano in the sisal country of the Tanga plains and an extensive planting programme has been undertaken. Both these stations work in co-operation with Amani, where coffee and sisal also receive special attention. Another innovation is the Lubago Station, opened in 1931 in the Shinyanga district, with the objects of trying new and improving existing varieties of crops; also of instructing natives in better methods of cultivation. Cotton crop stations at Morogoro, Kingolwira, Ukiriguru, Lubago, Uzinza and Mpanganya have been reorganized and their work extended to include various problems of native agriculture. At Nyakato in Bukoba Province, the centre of the largest native coffee area in East Africa, there is an entomological branch station, and a tobacco experimental station is established at Iheme in Iringa Province. The annual reports describe results of research in addition to other departmental activities, and are published, like those of Kenya, in the more conveniently handled octavo form. In addition, a series of pamphlets is issued at intervals.

The Tanganyika Veterinary Department, centred at Mpwapwa, has a laboratory and experimental farm. It is noteworthy that the inclusion on the staff of a pasture research officer and a biochemist has led to valuable results on stock nutrition. Large annual reports are issued. The Department of Tsetse Research,

which necessarily works in close touch with the veterinary and agricultural departments, has been described in Chapter X.

In *Kenya* the headquarters of the Agricultural Department are at Nairobi, as are the Scott Agricultural Laboratories. Maize, wheat, fodder, vegetables, coffee, groundnuts, sugar-cane, etc. are studied. Subsidiary to the laboratories are two plant breeding stations, one at Njoro and one at Mau Summit, of growing importance, and there are stations devoted principally to native crops in Kavirondo, Kikuyu and at Kilifi on the coast.

The Veterinary Research Laboratory at Kabete is extremely well equipped and has been described as the Onderstepoort of East Africa. A good deal of research work has been published from Kabete on rinderpest, east coast fever, pleuro-pneumonia, helminthiasis and the virus diseases of sheep and goats. After the visit of Sir John Orr to Kenya in 1929, a government stock farm was established at Naivasha to investigate the feeding and selection of stock; but during the first five years' work, research was hampered by lack of funds and by drought and locust infestations and was mainly confined to practical feeding and costing observations. The Colonial Development Fund has, however, renewed the grant for a period of five years, and under the joint control of Sir John Orr and the chief veterinary research officer, the correlation of nutritional and reproductive activity will be studied by Dr. Anderson. The annual reports of the department cover both plant and animal industries, and many results of research are published in a series of bulletins.

Uganda has a large central agricultural laboratory at Kampala with a fifty-acre experimental plot. At Kawanda there is a cotton seed farm of 400 acres, and at Bukalasa a cotton experimental station of 300 acres (75 cultivated). At a conference held in 1935 it was decided to enlarge the Kawanda farm to take the place of Bukalasa and the plots attached to the Kampala laboratories, and to arrange for the technical officers of the agricultural department to carry on their work at the experimental stations rather than at a central laboratory. This plan took the place of a more ambitious scheme to concentrate all the agricultural operations at Kawanda, which is a far more suitable headquarters for work connected with the elephant grass country.

To serve the short grass areas of the Eastern Province there is an experimental station at Serere, which now covers 1,000 acres, the station having been enlarged to provide an adequate resting period for the land required for cultivation. The plots have in recent years been redesigned on the contour plan of cultivation, devised to arrest soil erosion. At Serere cotton breeding has been the most important work so far, but all other field crops suited to the area are also dealt with, and as it is situated in a cattle district, cultivation is carried out with bullocks. The problems of soil deterioration and erosion and of the utilization of kraal manure occupy a prominent place in the programme. Linked with Serere are a small number of demonstration substations of five to thirty acres each, a series of one-acre cotton variety trials scattered throughout the Eastern and Northern Provinces; and also a series of quarter-acre plots. At Bugusege there is a small arabica coffee experimental station which serves the Bugishu area, where approximately 1,500 tons of coffee per annum are now produced by natives. The annual reports are issued in two parts, of which the second is devoted mainly to work by the specialist research officers. A series of twenty-one circulars was published between 1920 and 1927.

The headquarters for administration and research of the Veterinary Department is at Entebbe, where there is a fine new veterinary laboratory. In addition to research activities, serum for immunization against rinderpest, pleuro-pneumonia, and other diseases is supplied to the whole protectorate. Government stock farms are maintained by the department at Koja, Sukulu and Soroti, and similar institutions at Mbarara and Lira are maintained by the native administrations concerned. At each of these centres a close study is made of the indigenous breeds, and the animals are kept in conditions similar to, but slightly better than those prevailing throughout the country, with a view to breeding out particular weaknesses. Koja, the largest, is in an isolated position on a peninsula in Lake Victoria which renders it favourable for extensive breeding studies. Annual reports are published.

Turning to West Africa, Sir F. A. Stockdale visited Nigeria, the Gold Coast, and Sierra Leone during 1935–6, and his report (1936) gives a full account of the organization for different branches of agriculture in those territories.

In *Nigeria* the directorate of the Agricultural Department is at Ibadan, where also are the central laboratories for chemical, botanical, and entomological research. In the Northern Provinces there is an additional centre at Samaru near Zaria with laboratories and an experimental farm for crops. Five miles away is the large government stock farm of Shika, which is devoted entirely to the improvement of native stock for the dual purpose of draught and milk production. In addition there are four other experimental farms, varying in size from 100 to 250 acres, devoted to both arable farming and animal husbandry; numerous smaller farms, of about 40 acres each, serve partly for experimental work and partly for demonstrations and there are still more numerous demonstration farms of ten to twelve acres. Selection work is carried out in all the local crops; both those grown for export and for food; but a main object of all these farms is the study of problems connected with the new system of mixed farming which is being successfully introduced. These problems include management and nutrition, the new field methods necessitated by the use of cattle-drawn implements, rotations based on the use of farmyard manure, the production of fodders and the improvement or creation of pastures.

In the Southern Provinces, in addition to Ibadan, there are four experimental farms varying from 52 to 500 acres, which deal with oil-palms, cocoa, citrus fruits, cotton and coffee among export crops, with kola and with native food crops such as yams, maize, cassava and beans. In all these crops, selection and breeding work is carried out by specialist officers and field experiments deal with rotations and other cultural methods. A special feature of study has been crop rotation with green manuring in place of shifting cultivation, which has been submitted to experimental proof over a number of years. Cocoa is studied at two special isolated farms. Problems connected with the export of pineapples, the local green-skin oranges and grapefruit are under investigation, and work has been started on the improvement of village poultry. Annual reports are published by the department and a series of annual bulletins, started in 1922, were discontinued on account of the economic depression.

The Department of Animal Health has a central laboratory and

a large stock farm, where animals are bred for experimental purposes and for the production of serum, at Vom on the plateau in the Northern Provinces. The bulk of the anti-rinderpest serum used in the immunization of cattle in the field is manufactured there, as are all the vaccines used in the immunization of cattle against blackquarter, pleuro-pneumonia and anthrax, and of dogs against rabies. At Kano, Sokoto, Katsina, Maiduguri and Yola, field veterinary laboratories have been erected by the native administrations mainly for the manufacture of rinderpest spleen-vaccine for local use. At the Kano laboratory anti-rinderpest serum is also produced to augment the supply from Vom. All these laboratory products are used for the large-scale immunization of cattle against the serious epizootics of the country; it is only by such means that the diseases which once decimated the Northern Provinces can be held in check and eventually eradicated. Cattle owners are now fully aware of the value of these prophylactic inoculations, which are given free, and are voluntarily bringing their cattle in large numbers to the immunization camps. The curative treatment of trypanosomiasis of cattle is also carried out on a large scale by itinerant native inoculators. These curative and preventive activities occupy most of the resources of the department, but some research into problems of animal disease is conducted at Vom. Hides and skins have also been a subject of study, particularly with a view to increasing trade in the valuable Sokoto red goat. For this purpose the department had been in close touch with the British Leather Manufacturers' Association in England. Improved methods in the production of ghee have also resulted from work at Vom. Annual reports are issued.

In the *Gold Coast* the Agricultural Department has central laboratories and a directorate at Accra, and four experimental stations. That at Tamale in the Northern Territories has an area of 600 acres (200 cultivated), divided into five-acre blocks. Experiments are concerned with methods of cultivation and manurial trials in relation to yams, cassava, groundnuts, rice, green manures and grasses. At Asuansi in the central provinces work is carried on with citrus-fruits and bananas. The station at Kpeve in Togoland is for crops typical of the forest country and the savannah lands, such as cocoa, cassava, cotton, groundnuts, maize, and other

native food crops. Cadbury Hall at Kumasi was intended to be an agricultural college for training Africans for the agricultural service; activities were much reduced in the depression years and at present its training functions are limited to courses for foresters. Some research is in progress there and on the experimental farm attached. The Hunter Hostel is used for two months training for African farmers. There is a botanical garden at Aburi near Accra of about fifty acres on which investigations are carried out with local crops and ornamental plants. It is planned to begin trials with tea there also. In addition, three local stations are maintained for rice, coco-nut, and shea trees respectively.

The organization of co-operative societies in the cocoa industry is a special function of the agricultural department. In addition to annual reports, a series of agricultural bulletins has been published since 1925, containing results of research and departmental activities. Included in the bulletins are year books for 1926–30, each containing many papers on scientific aspects of agriculture, but since 1930 the publication of year books has had to be suspended. The *Gold Coast Farmer*, a journal designed to inform the general public on results of research, has appeared monthly since May 1932.

The Department of Animal Health has its centre at Pong-Tamale in the dry Northern Territories, where there is a laboratory devoted partly to serum production, the most recent of the African veterinary laboratories to be established, and a large stock farm where research is undertaken on animal breeding and nutrition. The tsetse fly problem has also been subject to experiment at Pong-Tamale as mentioned in Chapter X. One of the veterinary officers is stationed in the Accra Plains, a region of low rainfall near the coast, where opportunities are offered for a considerable stock industry. Annual reports are the only regular official publications of the department.

In *Sierra Leone* the Agricultural Department is centred at the Njala Laboratories. There are three experimental farms. That at Njala is for general research work, including the improvement (by selection) of upland rice, the investigation of maintenance of fertility, the selection and breeding of oil-palms, and other investigations with citrus, coffee, kola, pepper, etc. At Rokupr there is a

farm for the improvement by selection of wet land rices. Deep-water rices and salt-resisting strains are also being tried in the Scarcies area under the supervision of the Rokupr farm. The Newton Fruit Farm is for the improvement of cultivation, especially that of bananas and pineapples. In addition there are seven sub-stations run in connection with the three principal stations for the purposes of demonstration, seed supply, and young plant nurseries. There is also a young plantation (about 2,000 acres) of oil-palms at Masanki. The buildings at Njala were constructed at the cost of some £34,000 as part of a large scheme for a centre for agricultural training and research. Owing to changes in policy and to the economic depression no training was ever given there, and a new scheme, less ambitious, but designed to use the existing buildings, is now under consideration.

On the side of animal husbandry and veterinary research there is no provision at present in Sierra Leone. Cattle are few and are not used for draught purposes, except for ploughing in a few small areas under the supervision of the agricultural department. Nearly the whole of the country is overrun with tsetse, and most of the stock for slaughter is brought in from neighbouring French territory. The possibility of breeding a local strain resistant to trypanosomiasis has been discussed, but development in this direction awaits the appointment of a stock expert. Up to 1929 the department issued leaflets and pamphlets, but its only recent official publications are annual reports.

In the *Gambia* the Department of Agriculture has its headquarters at the experimental station at Yoroberi-Kunda in MacCarthy Island Province, where groundnuts, sorghum, cotton, rice, leguminous and miscellaneous crops are grown. Breeding work is carried on at the Wuli experimental station. Annual reports are published.

Somaliland has no experimental stations, but trials of maize, barley, sorghum, legumes for green manure, potatoes, groundnuts, etc. have been carried out on an experimental plot. Annual reports are multigraphed, but not printed.

Interterritorial conferences of agriculturalists and veterinarians have been held from time to time both in East and West Africa. Such conferences have been more frequent in the east, where they are

held under the auspices of the Conference of East African Governors. They include a general agricultural research conference at Amani in 1931 (Conference, East Africa, 1931), a conference on the co-ordination of agricultural research and plant protection in 1934 (Conference, East Africa, 1934a), and another in the same year on the co-ordination of veterinary research (Conference, East Africa, 1934b), and in 1936 another general agricultural conference at Amani on questions relating to the future of research in East Africa (Conference, East Africa, 1936). Other similar conferences of soil chemists and trypanosomiasis workers are referred to in Chapters V and X. In West Africa there have been two conferences of Agricultural Officers, the first at Ibadan in Nigeria during 1927, and the second in the Gold Coast in 1929 (Conference, West Africa, 1930). A vetinerary conference was held in Nigeria, at Vom, in 1932, attended by representatives from Nigeria and the adjacent French colonies of Niger, Chad, and French Cameroons.

Outside the government organizations, but in close co-operation with them, the *Empire Cotton Growing Corporation* maintains eight experimental farms in Africa and employs several experts at government laboratories. In Nigeria at Daudawa, on the road between Zaria and Sokoto, a seed farm of 1,280 acres (not all cultivated) was founded in 1926, and has a staff of two officers. In Nyasaland at Domira Bay, Lake Nyasa, a station was founded in 1930: it has 150 acres, and a staff of three research workers. In Northern Rhodesia a selection expert works for the Corporation at Mazabuka. In the Sudan a staff of three is maintained at the Shambat laboratory. In Southern Rhodesia there is Gatooma Station (340 acres, staff of three), for which Government grants a subsidy and pays the cost of labour and experiments. The Union of South Africa has the largest of the stations, at Barberton, Transvaal, with a staff of eight. In addition there are two subsidiary stations at Magut in Natal (staff of one), and at Bremersdorp in Swaziland (staff of two). The Corporation has maintained a supply of trained officers for their scientific and agricultural activities in Africa by means of a scholarship and training system at Cambridge and Trinidad, similar to that for the colonial agricultural departments. This was started in 1922.

FRENCH

As a central institute in France for colonial questions, the *Institut National d'Agronomie Coloniale*, situated in the Bois de Vincennes, with M. Prudhomme as Director, is the principal centre for advancing training for the colonial agricultural appointments, and has admirable facilities for this purpose in the way of study collections and gardens where nearly all the tropical economic plants are established. It is hoped that the Institute will eventually become a centre for colonial research as well as training. The periodical publication of the Institute, *Agronomie Coloniale*, is designed principally to inform workers in the colonies of recent advances in their subjects in other parts of the world, but it also includes results of research, as does the *Revue de Botanique Appliquée et d'Agriculture Tropicale* published by the Laboratoire d'Agronomie Coloniale in Paris.

In *French West Africa* agriculture and animal husbandry form two component parts of the Service Économique, the other subjects under the same service being forestry and customs. The whole Service Économique is under a Director-General at Dakar responsible to the Governor-General, and each of the component subjects has an Inspector-General with a staff of Inspectors.

In addition to the inspectorate, each of the colonies comprising French West Africa has a local service of agriculturalists, veterinarians, or foresters, under a Chef-de-service in each case. As part of this organization a number of experimental stations are maintained, as mentioned below. But perhaps the most important centres for research and experiment in French West Africa are those of the Office du Niger situated in the Sudan in the area adjoining the Niger which are to be put under intensive cultivation as a result of irrigation schemes. Ségou is the centre for research work, and the newly built laboratories there house agricultural chemists, entomologists, plant breeders and plant pathologists. Apart from this staff maintained by the Office du Niger, there are comparatively few specialist officers permanently in French West Africa, but research work required in any colony is often carried out by visiting scientists who come from France for short terms of work. For such purposes the universities in France co-operate in a large measure.

In the government agricultural services French West Africa had the following European staff in 1936: 49 Ingénieurs d'agriculture, 76 Conducteurs des travaux agricoles, 13 Contrôleurs de colonisation, and 10 Surveillants, and in addition, each colony has a subordinate staff of African Moniteurs. On the veterinary side there are 37 Vétérinaires Européens, 48 Vétérinaires Auxiliaires Indigènes and 21 Surveillants au service zootechnique (Europeans). Most of the European veterinary officers, like the doctors in the medical service, are drawn from the military services, but some civil veterinarians are now employed and receive special courses of instruction in France at the Institut de Médecine Vétérinaire Exotique at Alfort, which was established in 1920. The African veterinary staff is trained at Bamako in the French Sudan, where a flourishing veterinary school provides a full three years' course (*see* Chapter XIV).

For the improvement of cultivation the following experimental or teaching centres exist. In *Senegal* there is a large station for studies on groundnuts at M'Bambey and a farming school at Louga for improving native cultivation of this crop. There are also the gardens of Sor and Hann, the latter situated close to Dakar, and both serving primarily as nurseries for fruit and ornamental trees. In the Sudan, in addition to the stations of the Office du Niger mentioned above, there are the farming schools of M'Pésoba, Zamblara, and Kakoulou which give practical instruction in the cultivation of cotton and groundnuts, and distribute seed. At Bamako and Katibougou there are nurseries for trees combined with horticultural stations. In the *Niger Colony* there are the stations of Kolo and Tarma as controlling centres for colonization schemes and for agricultural instruction. There is a pasture station at Filingué and another instructional centre at Kontoukale. In *French Guinea* the most important station is at Kindia, where there are laboratories and experimental stations for bananas. There are also the gardens of Camayenne for trials of industrial plants, with nurseries attached, the experimental and acclimatization station of Kankan in Upper Guinea for cotton, rice, groundnuts, and tobacco, the farming school of Tolo, and farms in charge of the Sociétés de Prévoyance at Télimélé and Macenta. The *Ivory Coast* has an important experimental station

PLATE V

IRRIGATION WORKS ON THE RIVER NIGER IN FRENCH SUDAN

Above: The barrage at Sotuba, near Bamako. The irrigation canal runs off to the right from the arches

Below: The great barrage at Markala, under construction (June 1935)

for oil palms at La Mé, where cultivation trials, selection, and analyses of the products are carried out. At the agricultural stations at Bingerville and Gagnoa there are nurseries for bananas, coffee and cacao. There is an agricultural school at Saria, where cereals, cotton, and kapok are the principal crops dealt with, a farm at Poundou for groundnuts, cereals, and cotton, and a nursery at Basfora for fruit, forest, and ornamental trees. *Dahomey* has an important experimental station for oil-palms at Pobé. There are also a garden at Porto Novo with nurseries for coco-nut and coffee in the neighbourhood, a station at Niaouli for educational work and the study of coffee and fruit trees, and an experimental farm at Ina for groundnuts, cotton, cereals, and castor-oil.

On the side of animal husbandry the *Sudan* is the most important colony, and has a station at Sotuba for cattle, sheep, and small stock, as well as three stations for merino and karakal sheep and Angora goats at El-Oualadji, Nioro, and Nara. The goats have been introduced with success and have been inter-bred with the local stock. In *Senegal* the groundnut station at M'Bambey also carries out work with sheep and donkeys. In *French Guinea* the farm at Télimélé deals with cattle. The Ivory Coast has two stations for cattle and small stock at Bouaké and Koroko. In *Dahomey* the station in Ina deals with cattle, and in Mauritania there is an experimental sheep farm at Méderdre. Research on animal diseases and the preparation of sera and vaccines is centralized at the veterinary laboratory at Bamako in the Sudan. Branch laboratories, mainly for sera production, exist in all the colonies except Mauritania, and the Pasteur Institute's laboratory at Kindia in French Guinea also co-operates in this work.

Unfortunately the French services in agriculture and animal husbandry do not publish annual reports, and so the results of research at the stations mentioned above are somewhat scattered. Among other journals the *Bulletin du Comité d'études historiques et scientifiques de l'A.O.F.* contains a number of such reports, whilst the *Annales Agricoles de l'Afrique Occidental*, published at Bingerville, is a most interesting new venture.

In *French Equatorial Africa* parts of the country have, like French West Africa, proved highly suitable for cotton and a considerable organization exists for the development of this crop. There are

four stations, established about four years ago, where selection is carried out. They are managed by the Cotton Association consisting of four operating companies, but assisted also by government funds. The cultivation of coffee is also encouraged, and a small experimental station has been started recently. Interest in animal husbandry is concentrated in the northern part of the territory where cattle and sheep abound in the Sudan belt. In Chad colony there are five European veterinary officers, a sheep expert to look after imported flocks of merinos, and about one hundred African subordinate veterinary workers. No livestock breeding station has been established yet, but diseases, especially rinderpest and pleuro-pneumonia, are controlled by the use of serum and vaccine made locally. Sheep have been developed particularly in the neighbourhood of Chad where the veterinary service is concentrated.

BELGIAN

As headquarters for agricultural development in the Congo, there is a department of the Ministry for Colonies in Brussels under M. Claessens. In addition to the official services, several Belgian universities, notably that of Louvain, have taken great interest in the problems involved and have developed independent organizations in the Congo itself. The organization of services has been described in detail by E. Leplae (1932). Up to December 1933, agricultural development and research in the Congo was organized by La Régie des Plantations de la Colonie. In that year the Institut National pour l'Étude Agronomique du Congo Belge (INEAC) was established by royal decree, and now corresponds roughly with the official agricultural and veterinary services in the British colonies. Some account of its work is given below.[1]

The INEAC in 1936 had nine experimental stations, including five large stations in the Stanleyville district, with a total area of about 2,000 hectares (nearly 5,000 acres), two cotton stations at Bambesa and Gandajika, a station at Nioka for other crops, and the botanic gardens at Eala.

The five stations near Stanleyville are as follows: 1. Yangambi, on the Congo, where research is proceeding on rubber, especially

[1] From notes supplied by M. Claessens of the Ministère des Colonies.

the substitution of grafting for seed propagation, and experiments with different types of planting systems in relation to oil-palms and coffee. 2. Yangambi-Selection (about 100 hectares), where there are four sections, for oil-palms, rubber, coffee, and native food crops. The research, to which much importance is attached, consists mainly of long-range studies under the headings of (a) selection of pure strains, (b) experiments on germination, transplanting, dispersal, soil treatment, rotation of crops, harvesting methods, grafting, and prolongation of life, (c) biology and genetics, especially factors leading to fertility and the evolution of various characters. 3. Gazi (over 500 hectares) chiefly for rubber and cacao, with some oil-palms. 4. Lula, where 193 hectares are under coffee of different kinds, chiefly *robusta*. Work is proceeding on selection, seed distribution to planters, growth, reclamation of old plantations, cover crops and manuring. Wild coffees from the neighbouring forests are being studied. 5. Barumba, a very old station on the Congo River, where 560 hectares are under oil-palms with 354 hectares of cacao trees alternating between the palms. Work concentrates on growth and selection methods, and on the improvement of exhausted soil. The cotton station at Bambesa has 27 hectares of cotton and 20 of legumes. That at Gandajika has 30 hectares of cotton and 15 of legumes. Research is proceeding on growth and selection and on the control of pests.

Nioka is the principal livestock research station in the Congo. It is situated west of Lake Albert, 1,800 metres above sea-level, and covers some 2,000 hectares. Most of the area is natural pasture, but there is some improved pasture, some wooded land, and a part is devoted to food crops and to coffee. The livestock includes cattle, pigs, sheep, goats, and fowls. The station aims at the introduction of new kinds of stock, improvement by breeding, and the supply to settlers and natives of the most suitable kinds. The breeding of woolled sheep is promising, but up to now diseases, especially parasitic worms, have proved difficult to control. Important work on milk production is in progress, and natives are taught to train oxen for the plough. The crops studied are wheat, barley, rye, apples, pears, peaches, and avocado pears.

The botanic gardens at Eala, on the River Ruki, in the province of Coquilhatville, cover about 150 hectares. Up to now the gar-

dens have been used as a centre for collecting living specimens of the indigenous flora and for acclimatization experiments. Some 3,500 species of plants are growing there, of which about half are indigenous. In addition to work in the gardens, which is to be reorganized by the INEAC on more scientific principles, experiments are progressing at Eala on the breeding of dwarf cattle from Dahomey and Guinea, which show resistance to trypanosomiasis. There are also at Kisantu the famous botanical gardens of Fr. Gillet.

The INEAC proposes to reclaim immediately the old high-altitude station of Mulungu-Tahibinda at Kivu, about 2,000 metres above sea-level, for the purpose of studying arabica coffee, quinine, tea, and essential oil plants, all of which have been established there. In the Bas-Congo suitable land is being sought for development as a station for tropical fruit—bananas, citrus, pineapples, etc. This may be either at Mayumbe, or between Matadi and Leopoldville.

For the control of animal diseases there is a corps of European veterinarians, numbering some thirty-five, who have received a short course of training at the Institute of Tropical Medicine at Brussels in addition to having the usual qualifications. A laboratory for the production of serum and vaccine is situated at Kisenyi in Ruanda.

In addition to the INEAC there is an independent organization known as the Centres Agronomiques de l'Université de Louvain au Congo (CADULAC), which aims directly at improving native agricultural methods and local food resources. Like its sister body the FOMULAC (see Chapter XV), this originated in 1931 at the Congress at Louvain of the Academica Unio Catholica Adjuvans Missiones (AUCAM). Up to now activity has been concentrated in the region of Kisantu-Lemfu, in the Madimba territory of the Bas-Congo, where there was already a flourishing Jesuit mission, so that it was easy to get into direct touch with the natives.

The principal Belgian technical publication is the *Bulletin agricole du Congo Belge*, which contains results of research. In addition, the *Revue d'Agriculture et d'Élevage*, privately published, is partly subsidized by the agricultural department of the Congo.

PORTUGUESE

In Lisbon a central department of agricultural services at the Colonial Ministry has charge of all services in the Portuguese colonies. At present this department includes veterinary services, but plans are going forward for the organization of a separate department in Lisbon for animal husbandry.

In Angola and Mozambique there are departments for agriculture and animal husbandry under independent management. The following note[1] applies only to the veterinary organization, since information on agriculture unfortunately is not available.

In *Mozambique* a central laboratory for veterinary pathology, to include also the preparation of serum and vaccine, has recently been established at Lourenço Marques, and a central zootechnical farm, some eighty miles distant, is being enlarged to extend work in animal husbandry. Subsidiary stock farms exist in regions where cattle are most concentrated. European veterinary officers are also at work in the different provinces and apply measures of sanitary inspection, vaccination, dipping, and regional quarantine.

In *Angola* a central laboratory is under construction and part of it is already in working order. Situated in the highlands, it is intended for pathological research in addition to the production of serum and vaccine. In the Ganda district there is a zootechnical station specially intended for the production of meat. In the Humpata district, the high plain in the south, there is another station for the production of wool, milk, and working beasts. The Cuanhama district has a large establishment which, together with a native breeding centre, examines the question of the improvement of beef-producing cattle and of horses, and likewise of mutton-producing sheep. In Quilengues, the central coastal region, there is also a station for the production of beef and mutton. Scattered throughout the rest of the colony are smaller breeding farms affiliated to the principal stations, and centres along the coast exist for the purpose of making an intensive survey of all animal products exported from the territory.

[1] From information supplied by Dr. d'Eca, Chief of the Veterinary Services, Mozambique.

INTERNATIONAL

The *International Institute of Agriculture* at Rome was founded in 1905. With the associated Bureau of Agricultural Science it has aimed since that time at collecting agricultural statistics and general information from all over the world and disseminating them through the medium of periodical and other publications. The institute is financed by an original endowment and by contributions from numerous countries, and maintains a considerable staff. Only a small proportion of the work relates directly to Africa, but certain of the publications are of marked value, particularly the directory of agricultural experimental institutions in hot countries, the directory of animal husbandry institutions, and the annual volumes, mainly on agricultural economics.

For some time there has been a division of opinion among the contributing countries as to the functions which the institute can best perform. Since its inception the annual mass of information has increased beyond measure, particularly in the realm of research. Meanwhile, most of those countries with extensive imperial interests have developed their own means of disseminating information: the Imperial Agricultural Bureaux, for instance, serve this purpose for the British Empire. The U.S.A. and Great Britain have been forward in suggesting a reform of the work, and in March 1935, the permanent committee of the institute decided, on the advice of a panel of scientists, presided over by Sir John Russell, that the institute should in future retire from the purely scientific side of the information service and should concentrate on the practical and international aspects of agricultural progress.

CHAPTER XII

CROP-PLANTS

INTRODUCTION

THE great majority of natives depend for subsistence on their own food crops rather than on the production of commodities for the market. Hence greater knowledge of these food crops is important. This depends upon research of the following types: 1. Surveys of the numerous strains of each crop, and of their suitability to different conditions. 2. Improvement in methods of cultivation. 3. Research on the control of disease. 4. Dietetic work on the nutritive value of foods. 5. The breeding of food plants to increase yield, nutritive value and resistance to disease. Several of these subjects have received special attention in parts of the continent, and a few examples of the work done are mentioned below. But on the whole, until within recent years, more effort has been directed to the improvement of cash crops than to that of native food crops, possibly owing to the more immediate results which can be obtained in the form of increased revenues.

It is generally acknowledged that native crops grown in small plots have a measure of natural protection from disease through the obstacles to the distribution of causative organisms, created by native agricultural methods. These obstacles are removed where large compact areas are farmed under a single crop, as for export purposes. Native food crops are by no means immune from disease, however, and the plant pathologist, combined with the breeder, must be called upon to find the solution. The breeding of resistant strains is usually more satisfactory than the discovery of direct methods of controlling disease.

Although little has been published in regard to native food crops, much information, especially on the economic side, has been

collected. For example, in Uganda, when the locust invasion came in 1931, it was possible for the agricultural department to recommend the extensive planting of locust-proof crops such as groundnuts, cassava, and sweet potatoes. Owing to co-operation between field officers of the administrative and agricultural departments this campaign was so successful that no famine reserves had to be drawn on throughout the locust invasion.

Passing to cash crops, it would appear possible at first sight to distinguish those grown by European settlers from those produced by natives. But recently so many crops established at first by settler planters have been adopted by native cultivators, that the distinction can no longer be made, except in so far as the investment of capital enables the European or Asiatic settler to employ methods which are not available to the native.

In some cases these economic crop-plants have been introduced from outside Africa within recent years; in other cases indigenous plants have been improved, often as a result of interbreeding with introduced strains of the same species. As examples of recent introductions, cacao in West Africa, and tea and wheat in the East, may be cited.

In view of the risk from variations in market or in climatic conditions, which is involved by dependence on a single crop, as well as the creation of an unbalanced agriculture, it has been felt desirable to establish alternative crops wherever possible. Developments in Uganda may be quoted as an example. This territory at one time concentrated on the cultivation of cotton, of which approximately 300,000 bales are produced annually by native cultivators. In Uganda this crop is comparatively safe owing to climatic conditions and the relative absence of pests. It was realized, however, that a slump in cotton prices would be disastrous, and also that soil erosion was becoming a serious menace in areas where this crop was grown in excess of its legitimate acreage. Efforts have therefore been made to stimulate native production of coffee, and lately also of tobacco. Difficulties in marketing the variable quality of native-grown coffee have been overcome by recent coffee-grading ordinances, and the native production in Uganda now includes 4,500 tons of coffee and 1,000,000 lb. of tobacco in addition to the cotton. A similar policy of creating a

more diversified agriculture has been adopted both among European settlers and natives in every territory.

The influence of organizations in England, such as Kew Gardens and the Imperial Institute, has been active in stimulating interest in subsidiary crops. Through their assistance the cultivation of tung oil, quinine, essential oils, and insecticides has been developed in different parts of Africa.

In breeding and selection, three objects have always to be considered—higher yield, better quality and resistance to disease. There are many examples from Africa where one or two of these aims have been achieved with success, but the combination of all three has yet to be realized, except perhaps in the case of certain strains of cotton. As mentioned in Chapter VI, diseases can be divided into those caused by insects, fungi or other plant organisms, virus diseases and eel-worm diseases. The role of insects not only in directly bringing about disease, but in transferring the causative organisms of other troubles, has been discussed in Chapter X. Another aspect of disease concerns the relationships of crops to wild plants which may serve as alternative hosts for pests, etc. The methods of cultivation offer numerous problems for each crop individually, some of which are mentioned in the following pages. In this connection it is important to recognize the change which has taken place in crop research during recent years. As pointed out by the recent Secretary of State for the Colonies (Ormsby-Gore 1934), the old idea of protection from pests by spraying and similar methods for the destruction of the organism involved, is giving place to the view that the best defence is through suitable nutrition resulting from improved agricultural practice. In this there are three lines of approach: those of the geneticist or plant breeder, the physiologist, and the nutritionist, to which may perhaps be added that of the ecologist who studies the environment and the optimum conditions of climate, soil, etc. for each crop. He points out that team work is essential for progress in these subjects and that probably most has been achieved in the past by research stations concentrating on one crop. Quick results are impossible even with a large team of workers, and hence there is need for continuity in research.

There seems to be a paucity of reference works on African crops,

though general information can be found in text-books of tropical agriculture. The Royal Botanic Gardens, Kew, has published as Additional Series XII of the *Kew Bulletin* a list of the cultivated crop-plants of the tropics and subtropics grown in the British Empire and the Anglo-Egyptian Sudan which shows their cultural distribution (Sampson 1936). For West Africa, especially Nigeria, Faulkner and Mackie (1933) devote several chapters to crops. Leppan and Bosman (1923) deal with the crops of South Africa. For French West Africa Perrot (1930) has written a large volume on vegetable productions, both wild and cultivated. In 1935 the Ministry for Colonies in Brussels produced a series of small pamphlets on the crops of the Belgian Congo, namely cotton, cacao, rubber, palm-oil, other vegetable oils, copal, and fibres. Most of these include a useful list of selected publications dealing with the crops concerned. Reference is made to special publications in the following pages, after the historical notes on Africa's crop-plants.

The order in which the various crop-plants are discussed is based on a questionnaire used in the preparation by the Royal Botanic Gardens of the list (Sampson 1936) mentioned above.

ORIGIN OF CROP-PLANTS

The cultivation of crop-plants in Africa dates back to prehistoric times and the continent has made valuable contributions to the crop-plants of the Old World tropics. There is little doubt that the sorghum crop originated in Africa and that it has spread from there to Asia, where it is grown from Asia Minor to Korea and is perhaps the most valuable dry-land cereal of the more tropical parts. To-day most of the races of sorghum with their numerous varieties are confined to Africa, and it is a matter for astonishment how these races have been maintained and evolved in a country where agriculture is based on shifting cultivation and only primitive methods of grain storage are known.

Similarly the bulrush millets (*Pennisetum* spp.) have been evolved in Africa and recent botanical research has shown that more than one wild species of this genus were involved in their production. There are numerous races in Africa and the crop is represented in

India where it is second only in importance to sorghum as a dry-land cereal.

It is uncertain whether the finger millet (*Eleusine coracana*) is of African or Asiatic origin. Africa certainly shows a greater variety in the number of types which are grown, but the cultivation of finger millet is largely confined to certain tribes in East and Central Africa.

West Africa has three other indigenous cereal crops. Two of these are species of *Digitaria*, which are known by the name of 'Hungry rice' and a cultivated rice (*Oryza glaberrima*), which is derived from the wild species *O. barthii*, and which occurs from the Gambia to Nigeria in numerous varieties.

At least three species of pulse crops are of African origin. The principal of these is the cow pea (*Vigna unguiculata*), which is a common crop of mixed cultivation throughout Africa and occurs in numerous varieties representing markedly different characters in the grain. *Voandzeia subterranea*, the Bambarra groundnut, is confined to Africa and Madagascar and occurs throughout the more tropical parts of the country. It possibly reaches its highest development in Nigeria, where it is a crop of some significance. *Kerstingiella geocarpa* is another very similar African crop which is confined to West Africa. *Cajanus cajan* is widely distributed through Africa and is probably of African origin, but if so it must have been introduced into India at a very early date, as many specialized varieties are now grown in that country.

Of oil-seeds, *Sesamum orientale* is undoubtedly of African origin, as the allied wild species are only found there. It must have found its way into Asia at a very early date; for India, Burma, China, and Japan have all developed many distinct and specialized varieties. It was introduced to the New World at the time of the slave trade, and is still grown in the Carribean area for domestic use. The oil-palm, which is always associated with man, belongs to Africa, and there can be little doubt that man has played his part in the development of the higher oil-yielding types.

West Africa has its own indigo industry based on an indigenous species of *Indigofera*. The artificial hills, which are such a prominent feature of the landscape in the neighbourhood of the northern

cities of Nigeria, where the indigo dyeing vats are situated, indicate the great age of this industry.

Africa possesses several root crops peculiar to the continent. At least three species of *Dioscorea*, two of which exist in many varieties at the present day, are derived from wild African species. This culture is mainly confined to West Africa where doubtless these cultigens originated. Besides yams, the Hausa or Madagascar potato (*Coleus dysentericus*) is an African crop which is widely distributed. *Plectranthus floribundus*, the Kafir potato, belongs to the same family of plants. In Southern Nigeria there is a leguminous root crop (*Sphenostylis stenocarpa*), whose flowers resemble those of the cow pea.

Of crop-plants received from Asia, the banana, which was being grown in the extreme west of Africa when Columbus first discovered America, was first introduced from there to the New World. In Hakluyt's voyages mention is made of the people of the Guinea coast bringing presents of bananas and oranges to the ships which traded there. The greater yam came from Asia, and there are numerous plants of Asiatic origin which are found near the east coast of Africa. East Africa also received an important pulse crop from Asia, *Phaseolus aureus*, the green gram of India. This is now widely distributed in East and Central Africa.

There is no doubt that the slave trade greatly contributed to the variety of crops which are now grown in Africa. It has been stated that the Portuguese deliberately introduced maize, the groundnut, the cassava, and the sweet potato from America into what is now Angola; for they realized that the frequent famines which occurred in that part of Africa greatly reduced the size and value of their living cargo. Judging, however, by the numerous varieties of these three crops which exist in Africa there must have been numerous introductions to different parts of the slave coasts and on numerous occasions. In fact the groundnut must have soon become established, for it was first introduced to Jamaica from the Guinea coast. The amazing thing about these American introductions is the rapidity with which they spread throughout the continent and the way the people adapted them to their methods of cultivation.

RESEARCH ON CROP-PLANTS

CEREALS

A survey of the *sorghums* (*Sorghum vulgare*) was inaugurated by the Economic Botanist at Kew Gardens, Mr. Sampson, in collaboration with the British colonial agricultural departments. The material collected has been critically studied by Mr. J. D. Snowden (1936). Mr. Burkill, on the basis of Snowden's work, has written an historical study of this cereal (1937). The co-operative study of this crop, which entailed a study on the spot of the agricultural characters of different varieties, has perhaps called attention to its importance, and several departments have carried on the work of improvement, notably in Northern Rhodesia, Nyasaland, Tanganyika, and Nigeria. The collection of material at Kew has also made it possible for officers of agricultural departments to make a special study of this crop when on vacation. In the Union of South Africa selected varieties of sorghum have shown marked resistance to 'witch weed' (*Striga*), a root parasite which causes great losses to this crop as well as to maize and certain other cereals.

Material of a large number of bulrush millets (*Pennisetum*) has been collected at Kew and has been critically examined and classified by Hubbard and Stapf. It has been shown that these millets have been derived from more than one wild African species (Fl. Trop. Africa, 1934). In Tanganyika bulrush millets have been selected to produce compact heads, and quick-growing varieties have been bred for dry areas.

In Nigeria the selection of pure strains has been undertaken with both grain sorghums and pennisetums at the agricultural station of Samaru in the Northern Provinces. This has resulted in increased yields up to 30 per cent, but results to date are somewhat erratic, and yields of 30 per cent over the average in one season have sometimes been followed by yields of 5 or 10 per cent under average in the following year. In general it can be concluded that strains of sorghum can be selected which give improved yields in the area where the selection is actually carried out, but appear to be incapable of competing with local varieties elsewhere, even if only fifty miles away. In the Gold Coast, where the Botanist devotes much

of his time to native food crops, the selection of grain sorghums and pennisetums forms part of the work of the agricultural station at Tamale. Similar studies have been made in the Gambia.

The finger millet (*Eleusine coracana*) has been discussed by Clements (1933) and Moffat (1933) in connection with the *chitemene* system of agriculture prevalent in Northern Rhodesia. Selection work is in progress in Kenya, Uganda, Northern Rhodesia, and Tanganyika, where collections of local varieties have been made.

The cultivation of *maize* (*Zea mays*) has now extended to most parts of Africa where climatic conditions are suitable. It has been the subject of research by the department of agriculture in the Union of South Africa for a number of years. In particular Dr. J. Burtt Davy, when Botanist to the Transvaal department of agriculture between 1903 and 1920, devoted a large part of his work to this crop and his text-book on the subject (1914) deals with all aspects of its history, cultivation, handling and uses, while more recently A. R. Saunders (1930) has discussed in detail the factors affecting the yield of maize in the Union. Studies on maize have made it possible for farmers to choose the varieties best suited to their particular area and the fertilizer most likely to succeed with any given type of soil. The breeding of drought-resistant varieties is in progress at the Kroonstad experimental station and at the Potchefstroom School of Agriculture. At Kroonstad valuable results have been obtained in the selection of yellow dent, in fertilizer experiments and in crop-rotation with trials maize and cow peas. At Potchefstroom a synthetic maize variety has shown promise, and experiments have been undertaken to demonstrate the advantages of winter ploughing. In Southern Rhodesia, at the Hillside station, a strain has been found which shows considerable resistance to infection by *Diplodia* and allied diseases. It has also been shown (S. Rhodesia 1936, *D.R.*) that yield and resistance to rust are increased by applications of lime.

In the colonial territories research on maize is in progress at several centres. For example, in Northern Rhodesia native varieties of maize have been collected by the ecological survey and have been subjected to selection trials, with a view to their suitability for cultivation at different altitudes. In Kenya selection has done

much to improve the yield of maize in the case both of settler and native production.

Rice (*Oryza sativa* and *O. glaberrima*) is a crop of increasing importance, particularly in West Africa. In Sierra Leone, for example, rice forms a staple food of practically all the population, and although large quantities are produced on the upland rice farms, an import of 10,000 tons per year was necessary until recently. The problem has been to increase production without affecting adversely the fertility of the upland rice farms, and the solution appeared unattainable until about ten years ago, when swamp-growing rice was developed in the Scarcies area. By 1935 some 30,000 acres of mangrove swamp had been converted into rice-fields and a small export had actually been started. Varieties have been introduced from India, Ceylon, British Guiana, and Indo-China, and strains have been selected suitable for the peculiar local conditions, as for example, 'deep-water rice', and one form has been acclimatized which will grow in as great a depth as eight feet. The type known as G.E.B. 24, an introduction from Madras, tested and multiplied at the experimental station at Rokupr, has proved most successful. Through examination of the product brought to the government rice mill, it is possible to ascertain the areas where diseases occur, and where methods of cultivation require improvement.

In Nigeria the pressure of population in the neighbourhood of the large native towns of the Southern Provinces has compelled the agricultural department to consider the development of new areas where food crops can be grown. Accordingly an investigation into the possibilities of developing rice-fields in the mangrove swamps in the neighbourhood of the Niger Delta has been made recently with encouraging results. Although such cultivation is rendered difficult by the proximity of salt water, so that only restricted areas of mangrove swamp can be used, it has the great advantage that the soil fertility is continually being replenished by the rise and fall of the water due to tidal action, so that its productivity is apparently inexhaustible.

In Tanganyika the department of agriculture has investigated the rice-growing area of the Pare district, where the native methods of cultivation have been found to be wasteful. Already a good in-

crease in production has resulted. During 1935 a native administration rice multiplication area was established at Mwabogole on the shore of Lake Victoria, where spacing experiments and strain trials are made. Selection work is also in progress at the experimental station at Mpanganya, Rufiji (Tanganyika 1936, *D.R.*) and improved strains of rice are now in cultivation. In Northern Nyasaland a survey of the local rices was made during 1930–2, and the results are published in a bulletin issued by the department of agriculture (Barker 1934).

In Kenya the rice production of the Tana River area has been greatly improved by the elimination of many varieties and the retention of a limited number sufficient to meet the needs of varying soil conditions while supplying the type of rice in local demand.

In the French colonies, R. Portères (1935) has made a study of native rices and the methods used in their cultivation in the north-west part of the Ivory Coast. Rice-growing enters into the programme of irrigated agriculture in the neighbourhood of the River Niger in the French Sudan.

With regard to *wheat*, the noteworthy breeding work which has revolutionized the industry in Europe, North America, and Australia has not yet proved of much value in Africa, since it appears that strains suitable to African conditions must be locally produced. Various aspects of wheat cultivation are studied in South Africa, and the genetic work on disease-resistant strains in progress at the Stellenbosch-Elsenburg College of Agriculture deserves special mention. Experiments with rotation, cultivation, and sowing methods are carried out at the Langgewens cereal experiment station, and the effect of different fertilizers on quality has also been investigated. Rotation trials of wheat with fodder crops are in progress at Jongensklip, and experiments in wheat cultivation under irrigation have been made at Hartebeestepoort. Dr. Burton in Kenya has been studying wheat and maize during the past ten years or so, and has obtained valuable results on breeding. Several suitable wheats, some of which are resistant to the two principal rusts prevalent in Kenya, have been evolved and are already in cultivation.

PULSE CROPS

In addition to the pulses mentioned on page 339, *Vigna unguiculata*, *Voandzeia subterranea*, *Kerstingiella geocarpa*, *Cajanus cajan*, and the introduced *Phaseolus aureus*, certain other crops are important. *Dolichos lablab* is confined to East Africa, from the Sudan to Nyasaland. Many varieties of *Phaseolus lunatus*, an American species, are grown in West Africa and it is occasionally seen in East Africa. Another American species, *Phaseolus vulgaris*, is cultivated in the cold season in East Africa in many varieties. *Mucuna aterrima* and allied species are grown in the Rhodesias, Nyasaland, and Tanganyika. This crop is regarded mainly as a food for times of scarcity owing to the poisonous property of its seeds, which entail boiling in many changes of water. The sword-bean (*Canavalia ensiformis*) occurs wild, and to a small extent cultivated, in West Africa. A study of *V. unguiculata*, on lines similar to those adopted in the case of sorghum, has been commenced by Kew in co-operation with the agricultural departments of the various British tropical dependencies.

The importance of pulses as an element of native diet, particularly in areas where they are the principal source of proteins, is now widely recognized, and in those territories where scales of rations for native labour are prescribed by law it is usual to include a fixed quantity of pulses. The increasing interest which has recently been taken in the nutritional problems of colonial peoples may lead to the further development of research on these important crops.

FODDER CROPS

Lucerne (*Medicago sativa*) is one of the best-known forage crops and is grown throughout temperate parts of the world. In South Africa a considerable area, amounting to nearly 100,000 morgen, is under lucerne, and Professor Leppan (1924) has written an exhaustive treatise on its cultivation there. More recently the Union department of agriculture has published a study of this crop (Tarpin and McKellar 1936). Lucerne has been found to have high nutritive value as food for human beings as well as for stock. Fox and Wilson (1935) point out that it is remarkably rich in vitamin C, in addition to containing a considerable amount of

mineral matter and protein. They suggest that it could be added with great advantage to the dietaries of mine labourers in South Africa.

In Nigeria the use of green manuring is being widely inculcated, and *Mucuna aterrima* and *Calopogonium mucunoides* have been found most generally suitable for this purpose. The latter also has proved of great value as a cover crop in plantation agriculture in Sierra Leone, French West Africa, and the Belgian Congo. In the Southern Provinces of Nigeria experiments have been made with various pulses with a view to isolating varieties which will serve both as cover crops and green manures, but none has so far been found which will form a really dense cover capable of preventing soil wash and strangling weeds.

OIL-SEEDS

The *groundnut* (*Arachis hypogaea*) is an early introduction from South America and must soon have become established as an important addition to the crops of the country, for it is recorded that this crop was introduced into Jamaica from West Africa at the time of the slave trade. Many varieties to which names are given are recognized by the people. As an export crop the groundnut is of most importance in the semi-arid regions of West Africa, where methods of cultivation and the selection of improved strains have been studied in both French and British dependencies. These plants are comparatively easy to work with, since, being self-fertilized, there is no need for precautions in the process of selection. In northern Nigeria there are two types of groundnuts commonly cultivated, one with an upright growth and the other spreading. By the simple expedient of selecting the best plants over a period of five years the upright kind has produced an increased yield of 25 per cent, and the spreading kind of 16 per cent. As there is not very much variation in the quality of groundnuts, efforts are directed mainly to producing greater yields. This is especially the case in those areas where groundnuts are grown for purposes of local food supplies rather than for export. 'Rosette' disease is a serious pest in many parts (*see* Chapter X). The Gambia, lying as it does in the midst of the groundnut region of Senegal, relies almost entirely on exports of this crop: improved methods of cul-

tivation are studied at Yoroberi-Kunda, and breeding at the Wuli experimental station. In Sierra Leone efforts are being made to increase production, since crops are not sufficient to meet the requirements of the local food market. In Eastern Africa there are many areas suitable for groundnuts, and a considerable production exists mainly for local consumption. In Tanganyika, however, exports in 1936 amounted to 23,000 tons out of a total of 38,000 tons marketed. Selection work is in progress in all the British territories.

Senegal has the greatest groundnut export of any country in Africa, and experience there is significant in view of the increasing interest in this crop elsewhere. In this territory rainfall diminishes with latitude north of the equator, from 50 inches per annum south of the Gambia to 10 inches on the Senegal River. The whole country can accordingly be divided into three regions for the purpose of cultivation, namely the dry region in the north, the middle region east of Dakar, and the wet region surrounding the Gambia River. The dry region in the north was formerly the most productive, and the Rufisque groundnuts exported from the port of that name were once all grown there. Now, however, the soil in the northern region has been seriously impoverished, and the central belt is at present the most productive. Since continuous cropping without a rotation would lead there also to infertility, great importance is attached to experiments with manures. The crop depends largely on the length of the rainy season, and the limit of production depending on rainfall seems now to have been reached. In the extreme north of the territory, along the Senegal River, small inundation canals have been constructed in a number of places to control the flood waters for groundnut cultivation, and in other dry areas it is proposed to construct irrigation wells.

The agricultural experimental station at M'Bambey, not far from Dakar, has been established for some ten years, and much work has been done, some results of which have been published by Rambert (1928) and Sagot (1935 and 1937). In addition to the selection of local strains, other varieties of groundnut have been introduced from India, America, and Natal, with the result that several types of groundnut are now considered to be perfectly adapted to each of the three principal regions of Senegal. Seed is

selected and distributed through the agency of the *Sociétés de Prévoyance*[1] on the principle that for 100 distributed 125 will be returned from the resulting crop. With regard to improved methods of cultivation, farmyard manure has been tried, but has produced very little improvement. Good results, however, have been obtained from the application of lime at the rate of three tons per acre. In 1934 this produced a 35 per cent increase of the crop, but such an application would be quite impossible with the type of extensive cultivation prevalent in Senegal. The same is true of the application of phosphate which the soil also requires. A. Chevalier (1933–4) has written a monograph on groundnuts and Trochain (1932) has published a general account of botanical and agricultural studies in Senegal concerned with the potentialities of the country for this and other crops.

Most of the groundnuts from Senegal are exported unshelled, so that the nuts are not damaged. Freight costs make this impossible, however, where the crop is produced at a distance from the coast, and in the interior regions both of French West Africa and Nigeria the nuts are decorticated before transport. Consequently the quality of the oil suffers from fatty acids which are evolved when the nuts are damaged in shelling or bruised in transport. In the north of Dahomey groundnuts are grown for local consumption and a small export trade has been started recently. There is also an export trade from French Equatorial Africa.

Simsim or *sesame* (*Sesamum orientale*) is an important adjunct to native diet and is commonly used as a flavouring. It is particularly rich in phosphorus and calcium (McCulloch 1929–30). Hence its cultivation is widely scattered throughout tropical and subtropical Africa, though it is usually grown only on small areas for domestic use. It is exported in considerable quantities from Nigeria, Tanganyika, and Uganda. In Nigeria, where it is usually known as *benniseed*, it is important in a few localities. In the Benue province it is grown extensively by the Munshi tribe, who developed the industry entirely independently, as pointed out by Faulkner (1933). Formerly the local product contained seed of a dark colour owing to a mixture of seed of other nearly related species, but this has been largely replaced now by a white benniseed free

[1] See page 397.

PLANT INDUSTRY IN FRENCH WEST AFRICA

Above: In Dahomey—the old method of expressing palm-oil by treading

Below: At Kayes in Senegal—decorticating groundnuts for export

from this mixture, with the result that the crop provides the principle source of revenue in Benue province.

Palm-oil and *palm-kernels*, derived from the oil-palm (*Elaeis guineensis*), are the principal export of all the territories bordering the Gulf of Guinea. The products also provide an important ingredient of the local diet (*see* Chapter XVII) of the people of West and Central Africa. Native rights of ownership are asserted over all oil-palms and some authorities hold that the palm is never really wild, but that its presence is an indication that the land has been farmed at some previous time. The native farmer, however, until recently, made no efforts to improve production other than by periodical clearing of surrounding vegetation in order to plant food crops. In the process fire frequently causes serious damage to the palm-trees, and it is common in West Africa to see groves of palms in which every tree shows a pronounced constriction near the roots, where fires have eaten into the trunk. West Africa has now to compete with the product of the large plantations of oil-palms established in Sumatra and Malaya. This has stimulated considerable research on breeding improved strains and on methods of cultivation, while efforts are being made through the agency of agriculture departments and co-operative organizations to persuade Africans to grow palms in plantations instead of relying on chance seedling trees.

The oil is obtained from two sources: palm-oil from the fleshy pericarp of the fruit, and palm-kernel oil from the kernels. The palm fruits of West Africa are of different types, varying from one which has a very thick shell, a large kernel, but a thin pericarp, to one with thin shell, small kernel, but a very thick pericarp. Most of the palm-oil is obtained from the thin-shelled varieties, and the kernel-oil from those with thick shells. The thin-shelled varieties are, as a rule, not such heavy bearers as the others, so the problem of selecting improved palms is to combine the merits of both types to produce a thin-shelled, high-yielding fruit. The breeding of oil-palms, as of other perennials, is slow, since the young plants cannot produce offspring for five or six years, and the final yield of the adult tree cannot be estimated till it is fourteen years old, though at about ten years, the proportion of oil obtainable from the nuts can be determined. Thus the selection of oil-palms takes

on the average about ten times as long as for annual crops.

In Nigeria work on this subject has been done for the past seven years by two plant breeders at Ibadan (Smith and Toovey 1938); the period is not, however, long enough to produce conclusive results. At Calabar large plantations were established in 1906, and records of their yields through this whole period provide valuable data. Cultural studies are progressing also in Nigeria at the agricultural stations of Umuahia, Benin and Onitsha. At the last-named station plantations have been established with progeny of the best Calabar trees, self-fertilized. They serve as a demonstration and as a centre for the distribution of seedlings to the dense population of the neighbourhood, who rely largely on the export of palm products for their income. The area of cultivated palms is rapidly expanding and the progress in 1936 shows an increase of 80 per cent. over the area planted between 1928 and 1935. (Nigeria, Agriculture, 1936, *D.R.*)

The kernels are merely extracted from the nuts and dried for export, but the pericarp is always subjected to some form of press, so that the oil can be collected into drums. Methods of pressing have been studied and small mechanical presses, made in Europe for grapes, have been introduced to Nigeria with considerable success. These presses sell at from £11 to £17, a price which, though as a rule beyond the means of the individual, can be raised by the small co-operative societies such as it is hoped to establish in the palm-growing areas. These presses extract much more oil from the pericarps than the old methods of treading, but even so, only 80 per cent. of the total oil content is made available. Large presses, which can only be worked on a factory basis, can extract 85 per cent. of the total oil; these are now established in many parts of the Belgian Congo, but they are not contemplated in Nigeria, since current policy aims at avoiding, as far as possible, the development of large-scale industry. The palm-oil factory is more suitable to countries where palms are grown in large plantations, a system which does not exist in Nigeria. In the British Cameroons, however, there are a few plantations. The United Africa Company has acquired one of the former German estates, and has planted some thousands of acres with palms, but the trees are not yet in bearing.

In the Gold Coast the export industry has declined in importance, but there is still a large internal trade, and it is suggested that the small presses used in Nigeria should be tried. In Sierra Leone most of the palms have the thick-shelled type of fruit, and nearly all are wild. Moreover, much of the oil is consumed locally as food, since there is very little meat or fish available for admixture with the prevailing rice diet. Nevertheless, palm products consisting largely of kernels are the principal agricultural export of the territory. At the Njala experimental station small plantations have been established from seed introduced from Nigeria, the Cameroons, the Congo, and Sumatra, and it is hoped to select varieties giving a high proportion of oil. The treatment of the young palms in cultivation is, however, regarded as more important than the kind of tree grown. The Masanki Plantation, of which 2,000 acres have been planted with oil-palms, one-quarter local types and three-quarters introduced from Nigeria and elsewhere, has been established by government to test the cultivation of palms on a commercial scale. Now that the trees are coming into bearing, it is planned to hand over the plantation, either to the United Africa Company or to a settlement scheme organized by the government (Stockdale 1936, p. 114).

Palm products are of great importance in several colonies of French West Africa. Three European companies have concessions for palm plantations in the Ivory Coast, the Union Tropicale de Plantations having the largest with 10,000 hectares. There are two centres devoted to the study of palm products, one the station de la Mé in the Ivory Coast and the other at Pobé in Dahomey near the Nigerian border, both of which have been established for some twelve years. Castelli (1928) and Blondeleau (1929) have reported on work at the former, and Houard (1928) and Rancoule, (1928) on the latter, while Lavergne (1930) has also contributed data. Chevalier (1931a) comments on the lack of a botanical collection at la Mé as a basis for selection work. He also points out that research is necessary to determine whether the growth in diameter of the trunk—a quality of importance since the nuts are easier to collect when the trunk is large—depends on the soil or on a hereditary factor. As in the British territories, a chief object of experiment is to increase the oil-bearing capacity of the fruit; in

Dahomey, for example, fruits at present consist on the average of some 30 per cent oil-bearing pericarp, 20 per cent kernel, and 50 per cent shell, and it is hoped to alter the proportions to 60 per cent pericarp, 20 per cent kernel, and 20 per cent shell. Opinions differ on the relative merits of introduced Deli palms and selected indigenous varieties. Nearly all the oil is expressed at present by primitive methods. A few years ago a large mechanical press was set up in Dahomey by the Compagnie Française, but its working has closed down because the peasant producers preferred to express their own oil. There are, however, some thirty machines for cracking the nuts for the extraction of the kernels now in use in Dahomey, and in the Ivory Coast mechanical presses, mounted on lorries which move from village to village, were introduced in 1930.

In the Belgian Congo the largest oil-palm plantations are those of Unilever, situated in a zone extending from about 5° N. to 5° S. L. Conrotte (1935) has published an account of the fundamental technical principles recommended; this deals with methods of soil selection, the establishment of seed beds and nurseries, cultural methods in the plantations, types of cover crops, the symptoms of the most important diseases and appearance of the principal insect pests. In addition to the creation of new plantations much work has been done in the improvement of the 'natural' palmeries —which may be abandoned native plantations—by thinning and replanting. Imported seed has here been found unsatisfactory, and breeding is based on indigenous varieties. Plantation methods are being studied with a view to securing the most advantageous conditions for the growth of the palm, while permitting the extension of plantation with the minimum of labour. Studies on seed selection and on other aspects of the biology of the oil-palm have been published by A. Beirnaert, director of the Yangambi experimental station (1933 and 1935) and the causes of acidification of the oil have been investigated by R. Wilbaux (1936).

The *coconut* (*Cocos nucifera*) is grown in plantations, chiefly near the sea. The dried kernel of the ripe nut, known as *copra*, is an important article of trade; the oil expressed from it is used for margarine and soap, and the refuse is made into oil-cake for feeding cattle. In British East Africa, apart from Zanzibar, the industry

is of little economic importance, partly owing to the effects of drought and locusts in Tanganyika in recent years. In West Africa, especially the Gold Coast, however, this industry has continued to expand, a large part of the production being consumed within the Colony (Gold Coast, Agriculture, 1936–7, *D.R.*). During 1935 a series of experiments with the 'Chula' copra drier were made, as the humidity of the atmosphere necessitates artificial methods of drying. The copra produced in French Togoland, where large plantations were developed under the German administration, is better in quality than that from the Gold Coast, because there is a compulsory system of inspection. Coconut growing is an important industry in Mozambique. Plantations extend all along the coast, but are most numerous in the Quelimane District, where some of the largest plantations in the world are situated. The industry is said to be capable of still further expansion by native producers there.

The state in which the product arrives at markets in Europe has been the subject of an investigation under Professor Munro at the Imperial College of Science and Technology in London. Badly preserved copra entails a loss to the producer, owing to the loss of weight before sale and consequent reduction in the price paid, though to the manufacturer the higher content of the stereic acids required for the production of margarine is an advantage. Much attention has been devoted by the department of agriculture in Zanzibar to improvements in the quality of copra. The storing of nuts in the heap, so as to allow them to mature fully before turning them into copra by kiln drying, has been actively encouraged. The department has also carried out seed selection work.

Nuts from the wild *shea tree* (*Butyrospermum parkii*) yield a solid fat, the chief use of which is for native food, but which has been exported from West Africa and, more recently, from Uganda. The Imperial Institute and the Royal Botanic Gardens, Kew, have co-operated in regard to variations known to occur in the fruit obtained from different areas in British West Africa. This industry may increase in importance with improvements in facilities, since large unexploited supplies exist in the northern parts of Nigeria and the Gold Coast. The selection of trees has been started by the

department of agriculture in Uganda, and trials with the effects of cultivation on wild trees have been carried out since 1922 by the agricultural department of the Gold Coast on the Yendi shea reserve; a marked increase in yield is reported. Here also yield data of individual trees have been kept and samples of nuts from different harvests have been investigated by the Imperial Institute with interesting results. The establishment of these plantations in French West Africa was recommended by E. Annet (1930), but the suggestion does not appear to have been taken up.

The soya bean (*Glycine max*), a plant which has a high nutritive value in addition to a variety of economic uses, has been subjected to experiment in a number of territories. Trials in Nyasaland have proved fairly successful, but those carried out in Tanganyika, the Gambia and Sierra Leone have led to the conclusion that the crop is unsuited to those territories (Tanganyika, Agriculture, 1935, *D.R.*, p. 124). In Southern Rhodesia there is a tendency in the better varieties for the pods to shatter the seed before the crop is reaped, and efforts are being made to remedy this defect by selection (Southern Rhodesia 1934, *D.R.*). The standard work on the soya bean is by Piper and Morse (1923).

FIBRES

Cotton. There exist in Africa more than one species of wild cotton and one of these is probably the ancestor of a cotton which can still be found under cultivation in the extreme north-west of Nigeria. Apparently any hold which this had among the people as a cultivated crop was largely lost when the cottons of the New World were introduced. This must have been at a very early date after the discovery of America. *Gossypium punctatum*, considered by Roberty (1938) to be merely a form of *G. hirsutum*, is still a common crop grown for local use in the dryer parts of West Africa from the Gambia to Nigeria and is being utilized in cotton breeding work at the present time.

Besides this there are in Africa several races of the *Vitifolium* group of *G. barbadense L.* These are chiefly found in West Africa, but they also occur in Northern Rhodesia, Nyasaland, and Portuguese East Africa where they sometimes assume almost the character of trees, being grown as perennials in the house compounds of

the villages. Only one of this group has been developed as a major crop. This is the Ishan cotton of Nigeria, which on trial with other types of cotton was found to be resistant to a leaf-curl disease.

One may say that the whole of the cotton production, with this exception, has been developed from recently introduced seed of the Upland American cotton *G. hirsutum*, as far as British dependencies are concerned. The French have introduced varieties of *G. herbaceum* and *G. arboreum* var. *neglectum* into the French Sudan, and claim that these Old-World cottons are more suitable for the drier regions than are varieties of *G. hirsutum*.

The chain of experimental stations, some organized by and others assisted by the Empire Cotton Growing Corporation, are studying breeding, especially that of disease-resistant strains. The *Reports from Experimental Stations*, published annually by the Corporation, give full accounts of progress. Much of the work in Africa has been directed towards simple selection combined with self-pollination, but crosses have been sent from the Corporation's central research station at Trinidad, where also cytological study has furnished results of fundamental importance in plant breeding. The only other crop-plants on which the empirical results of experiment have been checked by cytological studies in Africa appear to be sisal and coffee, on which fundamental studies are in progress at Amani.

It has been suggested that some of the work on cotton has failed because useful types, which have been selected for one set of conditions, have not maintained these characters when transplanted to different conditions, but on the whole remarkable results are forthcoming. To consider first the introduced American strains of cotton, the Empire Cotton Growing Corporation's station at Barberton in the Union has shown the extreme value of the newly developed jassid resistant cotton known as U.4., strains of which are now in general use in the Union, Southern Rhodesia, and Nyasaland, and are competing with local selections in parts of Tanganyika and Uganda. Selection work with the various strains is still continuing. At Barberton crosses of U.4. with *Cambodia* have been made, and early and late strains have been compared. At Gatooma in Southern Rhodesia the present standard strains are being selected for jassid resistance; it is thought probable that

strains from Harland's *Cambodia* crosses will ultimately replace the best of the U.4. derivatives. Harland's *Cambodia* has also shown itself the best of the crosses tried at Domira Bay in Nyasaland. At Serere in Uganda the original U.4. has been crossed back with the local variety, and a strain has now been produced that preserves the hairy leaves and productivity of U.4., but in which the lint is more silky and much longer and closely resembles the style of lint for which a market has been developed. Another cotton recently bred in Uganda from American strains is S.G. 23/8. In many areas this appears to fulfil most requirements, but it is sometimes susceptible to disease. Evans (1938) has discussed the possibilities of growing Asiatic (short-stapled) cottons where climatic conditions do not favour the American (long-stapled) varieties.

In West Africa cotton has been the subject of botanical investigation in Nigeria, especially at Samaru in the Northern Territories. The original indigenous native cotton, although still grown in many parts of the Southern Territories, is practically replaced in the north by the Allen strain of Upland American. Experimental breeding from this has produced greatly increased yields, but strains which are fully resistant to disease, especially jassid and leaf-curl, have yet to be produced. A strain known as D.31 appears to be the most reliable, but is inferior for spinning. Farther south Ishan cotton, one of the *Vitifolium* groups of *G. barbadense*, has been improved by selection and distributed; it grows very tall and therefore is particularly suitable for interplanting with other crops, a type of agriculture which is common in parts of Nigeria and other countries which have only a short rainy season. In the south of Nigeria an introduced Sea Island strain is proving satisfactory.

With the long-stapled Egyptian cottons, notable advances have been made also, especially in the Sudan; for instance, Mr. Lambert, working at Medani, has selected the new Sakel strain 15/30, which is resistant to leaf-curl, shows recovery from blackarm, and on poor land in bad seasons has great resistance to climatic conditions, yielding in some cases nearly double that of the original stock. Similar progress has been made in Egypt with the new Giza strains.

On the side of agricultural management, great improvement

has been made with rotation of crops, but this is mainly of local application and the best rotations have to be worked out for each area. The object of rotation is to enable crops to draw uniformly on soil constituents, but in some cases it has proved of value in controlling disease.

This introduces another botanical aspect of cotton research, concerning the alternative host plants of pests. Thus during 1934 it was shown at the Mazabuka Station in Northern Rhodesia that, though climate and soil may be quite suitable for cotton cultivation, this will be successful only in districts where the food sequence of the cotton stainer is absent. A complete sequence exists in most of Northern Rhodesia owing to the prevalence of a perennial host plant, *Thespesia rogersii*. Again in parts of South Africa the American boll-worm is so much attracted by maize that a suitable rotation of cotton with maize leads to a reduction of the worm's attacks on cotton; and the beetle pest, *Sygarus*, can be controlled by a one-yearly rotation. In South Africa, Nyasaland and the Rhodesias jassid resistant strains have been produced and brought into general cultivation. Valuable work has been done by the Empire Cotton Growing Corporation in the study of crops suitable for rotation with cotton.

The times of planting, uprooting and burning of cotton plants are of great importance. By such means, not only can the best use be made of a small rainfall, but contact of the plants with the major wave of a pest may be avoided. A Belgian worker, Paul E.A. Jansenns (1932), has gathered a mass of information on cotton in tropical Africa into a most useful reference work.

Cotton has been a special subject of study in the French Sudan in connection with the Niger irrigation schemes. Forbes (1928) has described the studies carried out in early years, and further information is to be found in the unpublished reports of the Office du Niger and in a paper by Roberty.

In the Belgian Congo the two main areas of cotton are along the northern frontier, mainly in Uélé district, and along the rivers Sankuru and Kasai on the western border of the Lusambe Province. Native production is actively stimulated, marketing being organized through the *Compagnie Cotonnière Congolaise*. By 1931, cotton cultivation occupied over a million hectares, and 900,000

kilogrammes of selected seed were produced at the various experiment stations and nurseries. Records of yields in different areas are collected by agricultural officers and should lead to valuable conclusions regarding the suitability of different soils. Research is carried on at stations at Bambesa for the Uélé region and Gandajiha for the Sankuru. The work of these stations includes selection, multiplication of selected seed, study of cultural methods, control of degeneration and of plant diseases and experiments in the rotation of food or other crops with cotton. At Bambesa the entomologists have studied pink boll-worm, *Dysdercus*, *Helopeltis*, and jassids and have established that 'shedding' is caused by a capsid bug (INEAC 1934, *A.R.*). At Gandajiha the U.4 type has been found more satisfactory than local varieties. Studies on *Helopeltis*, the cause of stem canker, have been published by R. Steyaert and J. M. Vrydagh in 1933, and by the latter in 1936. Among other pests of cotton *Dysdercus* has been discussed by A. Buxhe (1936), and the pink bollworm by Vrydagh (1932), H. Bredo (1934 and 1936) and Mme. D. Soyer (1932). The two last-named have considered particularly the effects of disinfection by heating.[1]

Sisal (*Agave sisalana*) is a product mainly of Eastern Africa. Owing to its xerophytic character this plant can be grown in areas such as the Tanga plains and the floor of the rift valley, where the rainfall is not sufficient for other perennial crops such as coffee or tea. In Mozambique, where sisal has recently become one of the chief exports, production is confined mainly to the central regions and the area north of the Zambesi.

Sisal has been tried in some parts of West Africa, notably on the comparatively dry Accra plains of the Gold Coast, where, however, though successfully grown, it could not be recommended for native cultivation, owing to the high capital expenditure involved in the extraction of the fibre. Exports of sisal from French West Africa have increased in recent years; the principal centres of production are in the Sudan, but it is grown also in Senegal, the Ivory Coast, and Guinea. Considerable progress has been made at Amani in breeding sisal and other species of fibre *Agave*, and since the opening in 1934 of the new Sisal experimental station at Mlingano in Tanganyika, material has been transferred there

[1] See also Chapter X, p. 284.

from Amani. A new testing machine was designed and made at Amani in 1933, and as a result standard methods for sampling have been adopted. Another centre of sisal research is at Ngomeni in Tanga Province, where field trials and investigations of the sisal weevil have been in progress. Blue sisal, *A. amaniensis*, has been developed from a plant of unknown origin discovered near Amani in 1933 (Nowell 1933). This has been propagated, and in 1936 was established on a field scale at Mlingano (Stockdale 1937).

Researches which promise to be of much value in effecting a permanent improvement in the condition of the sisal industry in East Africa have been stimulated by the Imperial Institute. The inclusion of experts from the Admiralty on the Imperial Institute Committee on Vegetable Fibres has had important and valuable results, and a series of trials were made on sisal ropes side by side with hemp and other standard ropes. The results, published in the bulletin of the Imperial Institute (1931–3), have proved very satisfactory, and for many purposes sisal ropes are now issued to the Fleet. The Empire Marketing Board in the last year of its existence also paid much attention to sisal, and the resulting publications have improved methods of cultivation and the industry as a whole (Barker 1933). Research on the utilization of sisal and its by-products is carried out on behalf of producers in Tanganyika and Kenya by the Linen Industry research station at Lambeg in Ireland in co-operation with the East African sisal research organization.

ROOT CROPS

The root crops indigenous to Africa are *Dioscorea rotundata*, the common or white yam of West Africa, of which many varieties are grown; *D. cayennensis*, the yellow, negro or Guinea yam, a West African species of which also many varieties are grown, though it is less popular than the common yam; *D. hispida* var *dumetorum*, the Esuri yam of West Africa; *D. bulbifera*, the Akom or Air potato also found in Asia; *Coleus dysentericus*, the Hausa or Madagascar potato, which is grown throughout Africa and Madagascar wherever conditions are suitable, and extends as far south as Mashonaland; *Plectranthus floribundus*, the Kafir potato; and *Sphenostylis stenocarpa*, which is cultivated in Nigeria as a root crop. Early

introductions from Asia are *Dioscorea alata*, the greater yam, and *Colocasia antiquorum*, the eddoe or coco-yam. Early introductions from America are (1) *Manihot utilissima*, the cassava or tapioca. This is scattered throughout Africa wherever conditions are suitable for its cultivation, though it may miss areas where its poisonous properties have prejudiced its use. It occurs in many varieties, which are recognized and named by the people. (2) *Ipomaea batatas*, the sweet potato. This occurs throughout tropical and subtropical Africa in many recognized and named varieties. (3) *Xanthosoma sagittifolium*. It is uncertain when this was introduced and its close resemblance to *C. antiquorum* may account for this uncertainty. It is a matter of interest to note how these introduced root crops have been adopted by the people and treated as their own, and also how varieties have been recognized and evolved.

Cassava (*Manihot utilissima*), the root of which, when ground, gives the West African food known as garri, is a staple carbohydrate food almost equal in importance to cereals. Selection work and observation trials have been carried out in Nyasaland, Tanganyika, Uganda, and the West African territories. In Nyasaland, for example, the department of agriculture are distributing a type which is a heavy yielder and a quick grower. The plants suffer from a virus disease known as cassava mosaic. In the West this is thought to have been introduced and to be spreading inland, being carried by an Aleurodid fly (*see* Chapter X). Much attention has been paid to selecting resistant strains, but here, as with the millets and guinea corns, there are many local varieties, probably both of the cassava and the disease organism, and strains which are apparently resistant to mosaic in one area may not be so elsewhere. Satisfactory resistant types have been produced in Nigeria at Ibadan, in the Gold Coast at Kumasi, in Sierra Leone at Njala, where the infestation near the coast is in the neighbourhood of 90 per cent, and in Uganda. The progeny of these are being distributed to local farmers with reasonable success. In Uganda, for example, the resistant type of cassava is now important as a food reserve in those areas where famines were a feature of the earlier years of British administration. It is noteworthy that when resistant strains from Nigeria were tried at Amani, they succumbed to the East African mosaic disease.

In Nigeria during the last few years experiments have been made in producing *tapioca* from cassava by a simple process of grating and washing. An investigation as to the possibilty of establishing an export trade in tapioca was carried out by the department of agriculture in 1935, and it was decided that it would be more profitable to concentrate on the production of starch flour. (Nigeria, Agriculture, 1935, *D.R.*)

The manufacture of tapioca has been introduced in other territories also: for example, in French Togoland a factory has been established and an export developed. Each native farmer and his family perform every process for themselves, growing the crop, grinding the roots, washing the pulp through a series of tanks to float off the cellulose, cooking the pure starch and finally packing the finished product. It is claimed that an industry thus based on the family unit can be developed as an integral part of the ordinary tribal life. The adoption of these processes has been encouraged with a view to the development of exports; their application to the preparation of food for native consumption would probably increase the nutritive value of the plant, particularly in the case of the bitter cassava, in which the cyanogentic glucosides, which have been shown to produce pellagra, are more pronounced.

Sweet potatoes (*Ipomaea batatas*), which are widely grown for local food, exist in very numerous varieties. Variety trials, to test yields and quality, have been carried out in several territories. Trials at the Ngetta substation of the agricultural department, Tanganyika, showed that the best yielders were not nearly so acceptable to the native farmer as lower-yielding varieties, which have a better flavour. The trial of West African varieties has been carried out at the Samaru station in Northern Nigeria.

The vine of the sweet potato is valuable for forage and is also used as spinach by natives of West Africa. At the Shika Government stock farm near Zaria in Northern Nigeria sweet potatoes are in fact grown as the principal fodder crop. The vines last throughout the dry season, and they can be cut twice per annum at the expense of some development of the tubers. The tubers themselves form a valuable cattle food, but of course they are still more useful for feeding human beings. In parts of East Africa, notably the Kikuyu country, the sweet potato has been replaced

to a large extent by the *Irish potato* because the latter fetches a higher market price locally, especially from Asiatics and Europeans. Leakey (1934) has regarded this as an important factor in the overstocking problem, especially in relation to sheep and goats kept on cultivated land, because the vines of the sweet potato were formerly so valuable as fodder during the dry season.

Yams (*Dioscorea* spp.) are a staple food in many of the territories with high rainfall, especially in countries bordering the Gulf of Guinea. Their cultivation has been studied in detail by the Nigerian department of agriculture, but little has been done to improve the varieties. They are grown for distribution of propagating material, on native administration farms in Nigeria and the Gold Coast, and at Njala in Sierra Leone. The *air potato* (*Dioscorea bulbifera*) is another food plant which grows wild in West Africa and is cultivated in some areas, for example in Sierra Leone.

There are a number of minor crops, many of which are grown only locally. Of these, the *coco-yam* (*Colocasia antiquorum*) is important as food in some regions of damp climate, as in the cocoa-belt of the Gold Coast, and the south-east of Nigeria and the Cameroons. This plant is not related to the *Dioscorea* yams. It had long been thought that crystals of Calcium oxalate, always present in the roots, were injurious to health, but it has recently been shown in Nigeria that the bulb contains toxic substances which are responsible for this condition.

BEVERAGES

Coffee. All the cultivated species of coffee are African plants. *Coffea arabica* from Abyssinia is best suited to high altitudes; *C. robusta* and allied species are more tropical in origin and belong to regions with a higher rainfall; they are indigenous in the southern Sudan and in Uganda. *C. liberica* is indigenous to regions of high rainfall in West Africa. *C. stenophylla* is indigenous in Sierra Leone and neighbouring countries, and many of the wild coffees found in East Africa are closely allied to this last species, if not identical with it.

In the case of coffee, selection of improved varieties appears to be the principal requirement, but since there is a latent period of about five years before bearing, results can only be achieved

slowly. The subject has received some attention in Tanganyika, Kenya, Uganda, in the Congo, and in French West Africa. Work has been in progress since 1927 at Amani, which now collaborates with the new Coffee experimental station at Lyamungu, near Moshi in Tanganyika. Plants of arabica coffee have been transferred to Lyamungu, but the breeding is still supervised by the Amani geneticist. In addition to selection, vegetative propagation and other experiments are in progress with a view to finding out what factors influence variability (Tanganyika, Agriculture, 1935, *D.R.*). Intensive studies on the root systems of *Coffea arabica* have been carried out by Nutman (1934), and climates of coffee plantations have been studied in relation to the insect fauna by Kirkpatrick (*see* Chapter X, p. 287). Nutman has also thrown new light on the question of the value of shade by showing that the leaf stomata close up in full sunlight thus preventing carbon accumulation (Nutman 1937).

In Kenya pruning is an important feature of the investigational work both in the Kiambu-Ruiru area and at the Scott Agricultural Laboratories. Spraying, propagation, variety trials and diseases are included in the programme (McDonald 1937). Coffee selection has been progressing in Uganda for fifteen years, but little material has yet been published. There are, however, a number of promising selections under test (Thomas 1935). Mr. T. D. Maitland, who (1926) wrote an interesting history of *Coffea robusta*, produced in Uganda the type known as *robusta No. 9*, which is still the variety grown on many European estates, though during the last five years attention has been focused on the so-called Nganda types, which show considerable promise. The Government controls the supply of seed in districts where natives are encouraged to grow coffee, so that seed from selected trees only is planted.

In Western Africa *robusta* coffee is now grown in many parts of French and Belgian territory, but there does not appear to be much opportunity for the market to expand. Consequently coffee has not been a subject of special research in the British West African colonies; indeed it has been almost purposely postponed until work on other perennial crops, such as oil-palms and cocoa, is fully established. The view is taken that coffee can-

not be a profitable crop until the local peoples learn to drink it themselves; there is in fact a growing internal trade in coffee already established in the Gold Coast, and at the Njala agricultural station in Sierra Leone trials of coffee are now in progress with the same object in view. Coffee has been studied at the agricultural station of Bingerville in the Ivory Coast, and R. Portères (1934) has discussed a disease there which involves atrophy of the flower. It is ascribed to deficiency of fertile elements in the soil, but the best method of control has not yet been decided.

The botanical studies on coffee carried out by the Dutch authorities in Java, particularly in connection with vegetative propagation and selection, will doubtless prove of value to Africa.

Tea is a crop of growing importance in East Africa. As yet there is no special headquarters for research, but it is proposed to make a study of this crop particularly at the new Mlanje experimental station in Nyasaland. The lines on which work will probably be carried out are described by Dr. W. Small (1932). Mr. Hadlow (1934) has written a brief history of tea planting in that colony. The importance of understanding the relationship between the plant and the soil is fully realized, and the subject has been studied locally during the last few years in relation to both coffee and tea. The alkalinity and acidity at various depths (pH gradient) is the chief factor: thus coffee in suitable neutral soil (from volcanic rocks) grows roots to ten feet depth, but in acid soils only to a few inches. Tea on the other hand prefers acid soils, and Dr. Harold H. Mann (1933), when reporting to the Tanganyika Government on the prospects of tea growing, pointed out that a considerable redistribution of tea and coffee plantations is required. The acid soil of the Usambara Highlands, for instance, where coffee has been struggling for the last thirty years, is highly suited to tea, but useless for *arabica* coffee unless grafted on *robusta* stocks.

An excellent piece of work by H. H. Storey and R. Leach (1933), the plant pathologists at Amani and in Nyasaland respectively, concerns the disease known as tea yellow-leaf or tea-yellows, which has affected the crop in Nyasaland over wide areas, and is of particular interest from the ecological point of view. The general appearance of the disease was that of a fungal pest or a

plant virus, but when no disease organism could be discovered, experiments were made with fertilizers. This resulted in the discovery that the disease is due solely to a deficiency of sulphur in the soil and can be completely cured by the application of very small quantities of pure sulphur or sulphur-containing fertilizers. Sulphur is an element of which only very small quantities are necessary for plant life, and the solution of the tea-yellows problem suggests that deficiency in sulphur or other elements of which small amounts are required by plants, may be a cause of disease in other parts of tropical Africa. It is worth noting in this connection that Miss Sherbatoff, at the Imperial Bureau of Soil Science, is preparing a special report on all plant diseases which are known to be caused by specific soil deficiencies, a work which should be of much value to African scientists.

As a general matter concerning the cultivation of tea in Africa, it is important that the old-established tea areas of India, Ceylon, and Java have had to limit their output severely in recent years, and Russia is apparently increasing her output rapidly. Hence the chances for Africa in the world market may be relatively small.

Cacao. The development of cacao (*Theobroma cacao*) cultivation is a remarkable example of native enterprise and initiative. The methods by which this crop has been established and maintained, have been evolved by the native farmer practically unaided. The principal centre of cultivation is the Gold Coast, which derives a large part of its revenue from cacao exports; developments have recently taken place in Nigeria also, where cacao grows well in the high rainfall of the south-western areas. In the east, in spite of adequate rainfall, the poor soil renders cacao cultivation impossible.

The subject of cacao cultivation cannot be separated from that of forestry (*see* Chapter VII). Nearly all the cacao is grown on small farms, an area of forest being felled and burnt before planting. Sometimes a few large trees are left to provide shade, but the general effect in replacing a mixed evergreen forest with a single stand of cacao trees is to remove the two upper layers of forest cover. The single stand which remains is generally recognized to be far less efficient in retaining soil and atmospheric moisture

and avoiding run-off, so that the general effect of cacao plantations on water-supplies must be considerable. This question has been discussed by Sir F. A. Stockdale (1935) in a valuable paper on the relationship between agriculture and forestry. He has also described the methods of cultivation of cacao in the Gold Coast (1936).

It seems that all West African cacao is of much the same quality. Compared with those of Trinidad, the trees produce a higher yield, but have a much shorter life of twenty to twenty-five years instead of eighty to one hundred years, so that rejuvenation of the farms is necessary at regular intervals. Breeding and selection has been carried on in Nigeria since 1930, but few results are yet available, partly owing to the long life-cycle of the plant and partly owing to losses of young plants during the dry months of February and March. Selection has not yet been started in the Gold Coast, where also it appears that research facilities are not adequate to deal with the problems of rejuvenation. For these reasons, Stockdale advocates the establishment of a central cacao experimental station to deal with improved methods of cultivation as well as the production of high-yielding strains. Collaboration with workers in Trinidad and Nigeria is essential.

For the collection of statistics the department of agriculture in the Gold Coast has a special branch, and since 1927 all data have been kept and indexed. Study of these records has disproved the suggestion that the Gold Coast cacao crop was decreasing in size. The inspection of prepared cacao is another important activity of the department. Stockdale (1936) has recommended that the grading of cocoa, in addition to its inspection, should be taken over entirely by government in order to make the produce more equal in quality.

FRUITS

Bananas and *plantains* provide a staple food of natives in several parts of the continent, notably in the region of the great lakes. In Uganda twenty-four varieties of plantain are grown for experimental purposes at Bukalasa, and American types have been introduced (Thomas and Scott 1935). The weevil-borer (*Cosmopolites sordidus*) has proved troublesome and has been studied by the

entomologists since 1932. In Nyasaland also, selection of bananas is progressing at the Zomba experimental station. Mozambique exports bananas to South Africa from the district round Lourenço Marques.

In West Africa the centre of the banana industry is in the French Cameroons, from which large quantities are exported to Europe. The trade is still largely in German hands, and has expanded rapidly since 1931, owing to improved means of transport. Quantities of bananas are grown there by natives for food, and banana plantations have also been established by Europeans in French Guinea. The technique adopted, described by Chevalier (1931), is based on that in use in the Canaries. Some native plantations, for example, the Futa-Gallon, produce very fine fruit. In the Western Province of the Gold Coast efforts are being made to establish the banana export trade on a sound footing. So far the bunches produced have been small in size, largely owing to reduced fertility of the soil, and it has also proved difficult to persuade peasant farmers to give their plots the necessary amount of cultivation, in view of the comparatively negligible amount required for profitable cacao production (Gold Coast, Agriculture, 1935–6, *D.R.*). In his report Sir F. A. Stockdale (1936) urged that a survey of land suitable for banana cultivation should be made without delay. A fairly comprehensive survey has now been made by the agricultural department; some of the areas adjoining the Central Province Railway have been found very suitable, and farther west new roads are being constructed to tap other promising areas. Experiments to ascertain the best methods of cultivation are in progress at Asuansi and it is proposed to establish two or three demonstration farms. Reports on trial shipments of bananas are published each month in the *Gold Coast Farmer*, and methods of controlling disease are outlined from time to time. In Sierra Leone improved methods of cultivation are studied at the Newton experimental farm.

Citrus growing is a very promising industry in South Africa, and possibly Rhodesia. In the Union research is carried out at Nelspruit, Buffelspoort, the University of Pretoria, and by several commercial companies (Clark Powell 1933a). With a view to developing the industry in Nyasaland, Professor H. Clark Powell

(1933b) of Pretoria University visited the Protectorate and reported that the climate was suitable for citrus production, but that, owing to the marketing factor, oranges were more likely to be successful than other fruits. A limited production of grapefruit in time for the early summer market in the United Kingdom was warranted. As a result of his visit the department of agriculture have begun experimental work with citrus trees and an irrigation survey near areas suitable for cultivation has been started.

In Tanganyika orange-growing is for the most part in native hands, and little has been done to raise the standard of the produce but the small citrus station at Muheza has been established to make good these deficiencies. So far European planters have shown little interest in the industry, and it seems unlikely that the Tanganyika orange will be able to compete on the Bombay market with the South African product (Tanganyika, Agriculture, 1935, *D.R.*) The establishment of a small export trade in oranges and grapefruit looks hopeful in Nigeria, however, because the crop season there does not coincide with that of other countries, and it was decided in 1935 that the department of agriculture should encourage the commercial production of these fruits on a small scale (Nigeria, Agriculture, 1935, *D.R.*). In the Gold Coast a new nursery for testing varieties of citrus trees was established at the Asuansi agricultural station in 1935, the object being to select one or two varieties of each kind of citrus which are both suited to the climate and capable of producing good yields. Experiments in canning grapefruit are being made. There is a lime-growing industry now established in the Gold Coast and centred at Abakrampa, but by 1936 overproduction had become so acute that the agricultural department found it necessary to issue a warning to farmers not to plant any more trees (Gold Coast, Agriculture, 1935, *D.R.*). In Sierra Leone citrus trials failed at the Newton experimental station, but experiments are now conducted at Njala. Certain diseases have proved troublesome, especially scab disease, caused by a fungus, which curls the leaves and blemishes the fruit.

In Mozambique the district round Lourenço Marques is the most favourable for citrus cultivation. In 1931 more grapefruit than oranges were grown. Studies on grafting, selection, improved

methods of cultivation and control of insect pests by spraying and fumigation are in progress.

Viticulture is increasing in the Union of South Africa. Grape variety trials are in progress at the Paarl viticultural station in the Transvaal and the Oliphants river settlement. Improved methods of cultivation are studied, and in particular irrigation, since water is essential to this industry. Brak-resistant varieties of grapes are studied at the Oudtshoorn experimental station, and measures for controlling *Botrytis* rot of grapes are tested at the Stellenbosch-Elsenburg College of Agriculture. Here also experiments to determine the effect of root-stocks on the keeping quality of grapes are in progress. The correct export temperatures for different kinds of grapes are studied at the Capetown low temperature research laboratory.

MISCELLANEOUS

Tobacco (both *N. tabacum* and *N. rustica*) is an early introduction from America to Africa. It was a product of domestic importance long before Europeans attempted its cultivation outside Africa, and is still so in West Africa.

The chief producing country in Africa is Southern Rhodesia which, in 1935–6, produced 22 million lb., but it is not by any means confined to that region. Production in the Union amounted to 18 million lb. in the same period, and in Nyasaland to 17 million lb. Tobacco requires good drainage, and consequently terraced hill sides or sheltered tops of hills are best for its cultivation. It is also very liable to diseases caused by virus, eel-worms, and insects (*see* Chapter X). Some of these have been controlled by special legislation, for example, in Southern Rhodesia the Tobacco Pest Suppression Act was passed in 1933 to enforce the destruction of all plants left over from the previous season, which might harbour insects. The careful choice of rotation crops is another method of controlling disease, as in South Africa, where Rhodes grass as a rotation crop has been advocated by African Explosives and Industries, Ltd. (1935), since it is useful for fodder and is immune from eel-worm.

A study of the problems of cultivation in South Africa has been made by H. W. Taylor (1924). Until recently Rustenburgh has

been the main centre for tobacco research in the Union, but in 1937 the purchase of a new site at Kroondal for a station to be devoted entirely to tobacco was announced. Selection is made of plants for air-curing and flue-curing; for the latter Amerillo and White-Stem Orinoco have been found most promising. Fertilizer experiments are conducted by the Oudtshoorn station, in co-operation with farmers.

In Southern Rhodesia tobacco research is financed on the basis of an annual government grant of £5,000; any additional expenditure is divided between government and the tobacco industry. The research station at Trelawny has a staff of eight, with the senior plant pathologist in charge. Nematodes have been the subject of special investigation; an inquiry recently initiated concerns the possibility of the spread of the root gallworm by river water. Soil research has been carried out with special reference to tobacco, and experiments designed to improve the flavour of flue-cured tobacco have been undertaken by the chief chemist.

The Fort Jameson area of Northern Rhodesia has long been noted for the high quality of its flue-cured tobacco, and this industry, which has in recent years been hard hit by low prices, has now been assisted by a special tobacco station to study its problems. Here it has been shown that tobacco grown from newly imported seed does not fully thrive in its first season, but gives a good crop in the next year, after which there is an increasing tendency to coarseness and late ripening. Accordingly, the station imports seed annually and supplies growers from selected progeny. A rotation of two crops of tobacco followed by one of sunnhemp, which is ploughed in, and one of maize has been found satisfactory: a modification is now being tried in which the sunnhemp is cut and composted for application to the maize and the second tobacco crop. Trials of types suitable for native production were instituted in 1937 at the Mvuvye River. In Nyasaland studies on rotations, ridge-terracing and fertilizers have been made at Zomba and Lilongwe. In Tanganyika fire-cured tobacco is grown by natives in the Songea and Birharamulo districts, and by Europeans in the Iringa area. Some trouble with 'red-rust' has been experienced at Iheme experimental station, where new varieties from the United States of America were under trial in 1935. In Uganda the

crop is grown mainly by natives, and the plantings are strictly controlled by the agricultural department (Philpott 1935). Selection is carried out at Bukalasa and Serere.

In West Africa tobacco cultivation is limited to local needs, but in the Gold Coast and Nigeria the agricultural departments are trying to encourage growers to improve their methods of cultivation, in the hope of producing local tobacco in sufficient quantities to compete with the imported article. A large increase in the local consumption is expected as the standard of living of the 20,000,000 Africans in Nigeria improves. In that country the cultivation of tobacco on up-to-date lines has been started at Ilorin. B. Laufer, W. D. Hambly, and R. Linton (1932) have provided a general book on tobacco and its uses in Africa.

Rubber from wild sources has been mentioned in Chapter VII. The principal centre of Para rubber from plantations of *Hevea brasiliensis* is Liberia where the Firestone Company has a large organization. There are plantations under European management in Uganda and the Cameroons, and the African Lakes Corporation has an estate in Nyasaland. There are also some native-owned plantations in West Africa. Little development has taken place in recent years in view of overproduction in the Far East.

Ginger (*Zangiber officinale*) is grown in small quantities in parts of West Africa for local consumption as a medicine. The export of ginger from Sierra Leone is an old-established trade. The production of peeled and sun-bleached ginger for export is growing rapidly also in the Northern Provinces of Nigeria, and is providing a source of revenue for the pagan tribes. Cultivation and selection trials have been carried out by the agricultural department, and the sale of improved varieties to the growers has led to a marked increase in the size of the roots (Nigeria, Agriculture, 1934, *D.R.*). A grading system has also brought about the production of a better quality of ginger (Stockdale 1936). 1,500 tons a year are exported from that territory, but the methods of planting and preparation could be improved.

The native indigo industry of West Africa has been mentioned above (*see* p. 339).

Sugar-cane (*Saccharum spp.*) is of importance in a belt of land about 235 miles long and 10 to 25 miles broad along the coast of Natal.

One-third of the crop is produced on large estates and the rest by some 600 independent planters, of whom many are Indians. Research work is done at the Sugar Association Experiment Station, Mount Edgecombe, near Durban, of which Mr. Dodds is Director. Since 1926 the commercial cultivation of varieties other than Uba has been prohibited owing to their susceptibility to mosaic disease. Recently, however, improved varieties have been selected which may replace the Uba cane; the best are POJ 2725 and POJ 2878 from Java and CO 290 from India. Experiments on varieties resistant to streak disease are in progress at the Natal Herbarium.

Selection work is also being done in Kenya, Uganda, and the Gold Coast. An account of that in Uganda is given by the mycologist, Mr. C. G. Hansford (1935a), who has also made a study of the diseases of sugar-cane (1935b). In the Gold Coast the agricultural department is making a collection of imported types at Kumasi. Sugar-cane is cultivated in Mozambique in the valleys of the Zambesi, Limpopo, and Incomati rivers. The area under cultivation during 1929–30 was 22,500 hectares, and 70,000 tons of sugar were exported.

Kola nuts, which are chewed as a stimulant, are produced in West Africa from the trees *Cola acuminata* and *Cola nitida*. In Sierra Leone the kola trade is old-established; the territory has exported nuts to neighbouring African territories for a number of years, though latterly the imposition of protection and the development of local production have closed many of their former markets. Some trees, which produce inferior nuts, grow wild, but nearly all the product is obtained from trees grown by individual natives in their cultivation plots. Since the crop involves very little labour, production is steadily increasing. In Nigeria kola trees have been planted with success by the agricultural department on the poor soils at Benin and in the Eastern districts, where cacao cannot be grown, and the crop has assumed considerable importance.

The cultivation of *wattles* (*Acacia mollissima* and *A. decurrens*) is spreading in British Africa. The position with regard to wattle bark and other tanning materials has been summarized in a bulletin of the Imperial Institute (1927). The trees were first introduced to South Africa from Australia for use as pit-props, but an export of bark for tanning was soon established. Natal is the centre of

the wattle industry and cultivation has been so successful that the value of the products in 1930 was £2,000,000, of which bark for tanning represents 56 per cent, pit-props 33 per cent, and fire-wood 11 per cent. Improvements have been made mainly through silviculture, and the success of the wattle has served as a stimulus to other silvicultural research in South Africa. In recent years wattles have been established in Kenya, mainly as a native crop. An important industry has already arisen, and in the central provinces wattle bark has been the main exportable commodity (Kenya, Agriculture, 1933, *D.R.*). In the densely populated Kikuyu and Kamba reserves the tree has proved valuable for firewood and building.

Cloves form the main export of Zanzibar and Pemba Islands. Scientific study on the plantations is an instance where co-operation between agriculturalists and forestry experts has proved essential. A silviculturalist has been working recently in Zanzibar, and results of much importance to the whole clove industry will be published shortly. The Zanzibar experiment station had to establish five new nurseries in 1936 in order to meet the demand for selected seedlings from high-yielding parents. Regeneration trials indicate that it may be advantageous after clear felling stands of old cloves to put the land down to food and green manure crops for a few years before replanting. It has been found that the seedlings benefit by shade during the first year of life in the field and that interplanted cassava is the most suitable form of shade. Nutritional trials indicate that phosphates and possibly potassium are probably of greater importance than nitrogen to young cloves. Trials have been made to determine whether the clove is self- or cross-fertilized; and the means of control of the red ant and the clove chafer have been investigated. (Zanzibar, Agriculture, 1936, *D.R.*; Stockdale 1937.)

Tung oil is another tree crop only recently introduced to Africa. The trees (*Aleurites fordii* and *A. montana*) are indigenous to China, but the varnishes made from the oil were found to be so valuable that the Americans introduced it to Florida in 1905. In 1927 the Empire Marketing Board provided a grant to Kew to send seed to suitable Empire centres and to pay a research worker to experiment on the properties of Empire-grown tung oil and residue as

cattle-feeding cake, etc. The introduction appears to be yielding promising results in parts of the Transvaal, Natal, Tanganyika, and Nyasaland, but it cannot be regarded as an unqualified success. *A. montana* shows much more promise in the more tropical colonies, but so far the number of established trees is small. The production of tung oil in the Empire was surveyed in a memorandum by the Imperial Institute, issued by the Empire Marketing Board (1930).

Experiments have been tried with *Cinchona* in Africa. Quinine is still too expensive to be used as widely as would be desirable, and India is the only country in the British Empire where it is grown in any quantity. Plantations have been established at Amani for over thirty years; they have been very successful on a small scale, and supplied the German forces in East Africa during the war. Selection work and experimental grafting to extend these plantings on a larger scale is in progress, and a small industry has been established in the Usambara highlands in Tanganyika (Worsley 1935). Several orders for seed have been received at Amani from Kenya, and trials are being made also in Northern Rhodesia and Uganda, and in the Belgian Congo. The *Chaulmoogra* tree, which in India produces the oil so valuable in the treatment of leprosy, has also been grown experimentally in several parts of Africa.

The production of *essential oils* from peppermint, geranium, and lavender promises to become an important subsidiary industry, more particularly in East Africa. A special committee of the Imperial Institute, in collaboration with the Royal Botanic Gardens, Kew, has rendered valuable assistance in suggesting varieties and supplying planting material: this liaison between botanists and chemists has proved most fruitful. Valuable results have been obtained in Kenya where large geranium farms have been established near Nakuru, and research on geranium and other oils was carried out at the Scott Agricultural Laboratories. Cedar wood oil is another export. Experiments were being made in 1933 with Muhugu oil from the wood of *Brachylaena hutchinsii*, oil from a wild grass (*Cymbopogon afronardus*) and an oleo-resin from the wood of a small tree believed to be *Spirostachys africana*. In Tanganyika bitter-orange oil has been produced on a Seville orange plantation near Tanga, and the oil exported. Small quantities of

petit-grain oil have been marketed and it is hoped to produce lemongrass oil on a commercial basis in the Eastern Province. There has already been a small export of the latter oil. Results of research at Amani are outlined in a paper by the biochemist, Dr. R. R. Worsley (1934a). Experimental production of certain oils has also been carried out in Uganda and Nyasaland. In Rhodesia the production of citrus and other oils is being undertaken. Essential oils have the advantage of economic transport, since the oil is prepared on the farm, but production can only be profitable where labour, fuel and water are abundant. Considerable capital is required for the equipment necessary to deal with the raw material.

During the last five years a thriving industry has been built up in the Kenya highlands, in the production of dried *Pyrethrum* flowers for which there is a good demand in the manufacture of insecticides. The main producing areas lie between 7,000 and 9,500 feet and in general there is a progressive increase in yield with altitude between these limits. The average yield of dried flowers per acre is from 1,000 to 1,500 lb. The yields at lower altitudes are not considered economic under normal market conditions, but with the present high prices, cultivation is carried out at 5,000 feet upwards. *Pyrethrum* requires a fairly low average temperature and also at least one dry season a year in order to rest the plants. For these reasons trials at low altitudes in the tropics have so far proved unsuccessful.

Pyrethrum is grown in Tanganyika, under conditions similar to those in Kenya. The yield is approximately the same and a small export trade has now been started.

Derris is another insecticide crop which shows promise, particularly in East Africa. It thrives under humid tropical conditions and high quality material has been grown on a fairly large experimental scale at Amani in Tanganyika. Successful experimental work with derris has also been carried out in Nyasaland and Uganda.

Several other plants, used by the natives as fish poisons and similar in toxic properties to derris, are fairly widely distributed throughout the African continent. Among these may be mentioned *Mundulea suberosa*, *Tephrosia vogeli*, and species of *Lonchocarpus*, all of which have been investigated, but hitherto have not been found to compare favourably with high-quality derris.

CHAPTER XIII

PLANT INDUSTRY

SHIFTING CULTIVATION[1]

SHIFTING cultivation may be defined as any form of agriculture in which a patch of ground is cultivated for a short period of years until the soil shows signs of exhaustion or the land is overrun by weeds, after which the land is left to the natural vegetation while cultivation is carried on elsewhere. In due course the original site is usually planted again after the natural growth has restored fertility and checked the weeds of cultivation. This is the method followed by native tribes throughout the more densely vegetated parts of Africa. Two main types of shifting cultivation can be recognized: one in which the population moves to new quarters at frequent intervals, as new areas of forest are felled and brought into cultivation, and the other in which the people remain in fixed villages and open up new land within reach of the old habitations. The latter is essentially a rotational method which forms a perfectly sound basis for the introduction of improved methods of cultivation to avoid the dangers of soil deterioration.

After a long period of shifting cultivation the whole character of the vegetation may be altered beyond recognition. In countries with an equatorial climate, without a dry season, shifting cultivation usually changes virgin forest into secondary forest and thence to a kind of bush vegetation. This can be observed round every native village in the rain forests of the Congo or the Guinea lands. In regions with a marked dry season the usual effect is to change evergreen forest into deciduous forest and thence to a kind of parkland which resembles savannah, but in special circumstances quite different conditions may result. In Uganda, for example, there

[1] See also chapters V and VII.

are reasons for supposing that the elephant grass belt of the territory verging on the north-western corner of Lake Victoria was originally a dense monsoon forest, which has been destroyed by shifting cultivation.

Shifting cultivation is admirably adapted to the needs of primitive peoples, provided there is sufficient land available. The period needed for regeneration by natural vegetation varies according to conditions from four to twenty years. Before European occupation the balance between the number of population and the area of land was adjusted in most parts of the continent, so that there was ample time for rejuvenation. This is still the case in many areas: for example, in Uganda each village is a self-contained unit with its necessary requirements of reserve land. With the introduction of cotton as an export crop, however, the balance of nature has been upset, particularly where the rainfall is badly distributed. It is hoped that adjustments will be made in time by the movement of excess population into areas at present unpopulated, since in Uganda there is fortunately no lack of fertile land, which has not hitherto been required. Even in Uganda, however, the department of agriculture has found that the problem of soil deterioration requires serious study. In the past ten or fifteen years there has been an enormous increase of cultivation, perhaps amounting to 100 per cent and the problem has become, as elsewhere, one of inadequate rest periods. Here the main causes are the use of the plough and the introduction of *fixed individual* holdings in parts of the country. The department has instituted an agricultural survey as a basis for the redistribution of population and is investigating methods of manuring by composts, mulching with cut grass, and the planting of abandoned land with suitable grasses.

Since a detailed survey of the whole area is impracticable, the study referred to is based on a sample method, each agricultural officer being made responsible for one *mutala* or ridge, as the hill slopes in which native cultivation is carried out are called. In the absence of detailed agricultural statistics these surveys have considerable value, and they have an additional advantage in that data are obtained on the conditions of native food crops, the size of holdings, and systems of alternating crops in each of their areas.

Other parts of the continent are not so well placed, however, and districts can be selected where there has been a scarcity of land for a very long time. One or two instances have already been cited, but another worthy of mention is the Kikuyu reserve, where, as the Kenya Land Commission pointed out, the native population have destroyed increasing areas of forest throughout the few hundred years they have been in Kenya. As an example from West Africa, the densely inhabited district of Owerri in Southern Nigeria, where there are upwards of three hundred people per square mile in some parts, is suffering from pronounced pressure of population in spite of abundant rainfall well distributed through the year. In parts of Northern Nigeria, especially in Sokoto and Katsina Emirates bordering the Sahara, the reserves upon which over-concentrated populations draw for land can only be the forest areas which should be the heritage of posterity.

Conditions vary so much from place to place that generalizations on this subject are difficult, but it is clear that shifting cultivation is a principal obstacle to the conservation of forests, as stressed in Chapter VII. Where the choice of an area to be cleared lies between virgin high forest or regenerated bush forest, the native will nearly always choose the former because the soil is more fertile and free from weeds of cultivation. The choice is tempered by the kind of timber required for domestic purposes; since house-building requires straight poles, young forests may be preferred to ancient high forest. Fire is a principal element in clearing operations and the brushwood is invariably burnt on the spot. The wood ash adds to the soil fertility and the burning causes a partial sterilization of the soil, and temporarily checks the growth of weeds, so that heavy weeding may not be entailed for one or two years. In shifting cultivation the growth of weeds is often a cause for leaving the land equal in importance to loss of soil fertility.

The degree of destruction in making clearings varies considerably among different tribes. The stumps of trees and bushes are usually left in the ground since they do not impede cultivation with the hoe. This sometimes facilitates regeneration of forest, when the plot is deserted, but if soil erosion has set in during the intervening period, regeneration is greatly retarded. Some tribes appear to realize the necessity of maintaining tree growth on their

clearings and merely top the trees and lop the branches, so that the trees are enabled to recuperate quickly when the area is again allowed to revert to bush. An extreme case of destruction is that of the *chitemene* system employed in the cultivation of finger millet in Northern Rhodesia and the southern parts of Tanganyika. This is described by Clements (1933), Trapnell and Clothier (1937), and Moffat (1933), who has given a detailed account of the practice in the extreme north-east of Northern Rhodesia, where its evil effects are most evident. The *chitemene* (or *fitemene*) system consists in the burning of timber and brushwood from a wide area of land on one small part of it, so that the beneficial results of wood ash and sterilization of the soil are concentrated. The ratio of timber-area cut to area of cultivated land may vary up to 10:1, and the time required for regeneration of the pollarded trees may be anything from ten to thirty-five years. Sometimes the whole trees are burnt on the ground after being felled, or they may be killed by ring-barking and subsequently burnt standing. Trapnell and Clothier (1937) in describing the agricultural system of the Northern Plateau, give various forms of a modified chitemene system, which are employed partly owing to differences in agricultural traditions and partly to suit the varying local conditions. They conclude that although the practice may be held to improve poor soils, yet dependence on ash fertilizing causes gardens to be placed on soils of low fertility, with a view to obtaining suitably sized fuel. Professor Ogilvie (1934) discusses some of these practices in his communication on the results of inquiries made by the British Association committee on human geography.

The destruction of forest growth in closed forest areas is undoubtedly very serious, but some authorities consider that in open woodland the results are not so harmful as is sometimes suggested. The woodland is economically useless for the most part, except for certain species of trees which should be protected, and as regards erosion the stumps and roots may regenerate rapidly, so that the destruction of grass may be more important than that of trees. In some areas, through long occupation and the consequent distance of firewood from the villages, the roots are dug up and burnt, but this only occurs in well-occupied cultivation steppe, and not in the woodlands.

It is not intended to suggest that Africa is becoming overpopulated, but simply that the population is becoming too concentrated in certain areas for the primitive method of shifting cultivation. In other parts there is danger in the artificial stimulation of native production for export, which increases the amount of land under cultivation and so adds to the strain on its fertility. The dangers of the situation are fully realized by all agricultural departments, and in some areas efforts are being made to prevent its intensification by the two obvious methods of (i) redistribution of population and (ii) improvement in methods of native cultivation.

Some native agricultural systems include methods of protection against soil erosion. The primitive pagan cultivators of the plateau in Northern Nigeria pick stones from gently sloping land and arrange them in rows along the contours, so that soil wash is held up and the whole area of cultivation becomes terraced automatically. The same result is brought about by different means in some densely populated parts of Kigezi in Uganda (Thomas and Scott 1935, p. 117). On the steep cultivated hill-sides terracing is effected simply by leaving the weeds taken off the land in lines along contours at suitable distances. Soil wash is arrested by the weeds, and in course of time solid banks are formed, attaining in places a height of five feet. Similarly in the Kikuyu country weeds and crop residues are placed along contour lines. On flatter country mound cultivation, of which an advanced example is the mounding for yams, a common practice in many parts of East and West Africa, serves the same purpose. The extension of such practices to areas where they are not indigenous is one of the ways in which erosion may be prevented.

IMPROVEMENT OF NATIVE CULTIVATION

The serious situations which have arisen through native agricultural practice, outlined above and in the paragraphs devoted to soil erosion and deterioration in Chapter V, are recognized by agricultural authorities throughout the continent. Much work is in progress on the prevention of further damage to the soil and the improvement of native methods generally, but most of such work is of recent origin and at present there is little published

material referring to the results, except scattered references in annual reports of agricultural departments.

Perhaps the most obvious solution to the problem of erosion is to transfer populations from mountainous or sloping land to the plains and river valleys at lower levels, and this has been done with success in parts of the continent where pressure of population does not yet exist. This, however, is seldom practicable on a large scale; accordingly it is also necessary to find means of extending the period of fertility of cultivated land. The ideal, of course, is to render soil permanently fertile by instituting methods of manuring to counterbalance the strain on fertility which results from continuous cropping. But this ideal is not often to be achieved without a series of intermediate stages by which the period of cropping in systems of shifting cultivation is increased, and the period of reversion to natural vegetation is reduced. This, as the central problem of agriculturalists in many native areas throughout the continent, deserves discussion in some detail.

Nigeria contains the densest agricultural population in Africa, especially in the areas surrounding the large cities, and since there is no European community, agricultural studies have been directed entirely to the problems of native cultivation. Mr. O. T. Faulkner, until recently Director of Agriculture, in collaboration with Mr. J. R. Mackie, who has now succeeded him, has written a valuable book (1933) describing the agricultural situation in West Africa with particular reference to Nigeria. The following account is based on that work, together with information provided more recently by members of the department. For agricultural purposes the country can be divided into the Northern Provinces, with an arid climate and one rainy season, where cattle are farmed in large numbers, and the Southern, with a damper climate, two rainy seasons and very little stock on account of widespread tsetse fly. The south, however, must itself be divided into eastern and western regions, owing to the differences in soil. The east is covered with acid soils which are generally similar for agricultural purposes, although, on geological grounds, they are divided into Benin sands and alluvium. In the west, however, the soils are much richer and less acid. Hence, though every crop of the east will grow in the west, the converse is not true. Cocoa and cotton

are almost useless in the east, where also the yields from food crops, such as maize and yams, are only about half that in the west. The oil-palm, which will suffer poor soil but must have a high rainfall, grows better, however, on the alluvium of the Niger delta than on the richer soils of the western provinces where rainfall is less.

In the southern provinces generally, the pressure of population is sometimes so great that permanent cultivation is forced upon the people. The time actually allowed for fallowing varies from a proportion of about seven years' rest to one of cultivation where the population is fairly thin, to one year's rest to two of cultivation in the dense areas. In a few places the land has reached such a state of infertility that woody plants are incapable of regeneration, and even weeds take a long time to become established. Except in the densest areas there is not much erosion, but when the vegetation is removed, considerable loss of fertility results.

GREEN MANURING

To improve the conditions in Southern Nigeria, described above, the method of approach has been to protect the soil with cover crops, which, when dug in as green manure, extend the period of cultivation and reduce the period of lying fallow or reversion to bush. The combination of making mounds and contour ridges with cover crops and green manuring is generally considered to be the most practical way of combating loss of fertility. The process of green manuring is based on the double rainy season in Southern Nigeria, which enables two crops to be produced during the year, one of them being green manure. At the central research station at Ibadan experimental plots have been kept in permanent fertility with green manures for many years. It is realized that a new method will not be generally adopted unless its results are demonstrably more profitable, and do not involve a heavy burden of additional work, and all experiments are conducted with this consideration in view. In essence the system worked out at Ibadan consists of one green manuring with a leguminous crop, usually *Mucuna aterrima* or *Calopogonium mucunoides*, and a deep cultivation every three years. During the intervening period one or two cover crops are interspersed between the normal food crops, arranged at times when the soil is otherwise bare of vegetation. By such

methods the proportion of cropping years to fallow years can be reduced from 1:7 to 1:2.

In Southern Nigeria the establishment of Native Administrations is of more recent date than in the Northern Provinces, and until about 1930, it was not found possible to enlist their co-operation in agricultural extension work through the medium of demonstration plots and schools. As soon as the best technique for maintaining fertility in each area has been established, however, the methods of extension work now in existence should make it rapidly popular.

In the Northern Provinces of Nigeria the single rainy season renders the production of two crops during the year impossible, and therefore any attempt to introduce green manuring would be doomed to failure. In certain areas, for example in the neighbourhood of Kano, an intensive fixed cultivation is already practised and provides an interesting example of a native system especially suited to the environment. Permanent cultivation throughout the Northern Provinces will come eventually through the development of mixed farming, a subject which is considered later.

ROTATION OF CROPS

Green manuring has been the subject of experiments also in the Northern Territories of the Gold Coast, where, since 1929, large increases in crops have resulted from special rotational systems which include green manure. Thus a five-year rotation consists of (1) yams, (2) Bengal bean (*Mucuna*) as a green manure which is dug in, (3) cotton, (4) Guinea corn, (5) maize and groundnuts interplanted. This has given excellent experimental results, as also has a three-year rotation consisting of (1) yams, (2) Bengal bean, (3) maize and groundnuts. The usual native cultivation in this area involves two years' cropping followed by five or six years' fallow, but near the villages, where cultivation has been continuous for long periods, soil fertility has been much reduced. It is considered that the new rotations may be of value in native farming in the future, but at present land is so abundant, except close to the villages, that farmers would regard it as waste of a year's crops to plough in the beans.

In the North Mamprusi region very different conditions prevail from those just described, as shown by a recent survey undertaken

by the agricultural department (Lynn 1937). In this isolated community a primitive system of fixed agriculture prevails. The best soils are around the villages and are manured with cattle manure and the primitive habits of sanitation; lands farther distant are recognized as being less fertile and consequently receive less attention. In the opinion of the agricultural officers, conditions are ripe for the introduction of a more intensive system of mixed farming; experiments have been undertaken with rotations, cultivation, manuring, root crops, and so on, in this locality rather than at Tamale, where conditions are different.

In Sierra Leone, except for the wetland rice areas (*see* Chapter XII, p. 343) the general method of native agriculture consists in cutting temporary clearings in forest growth, from which crops are taken for one or sometimes two years. These crops usually consist of rice with a small proportion of guinea corn and millet. Sometimes a small admixture of perennial cotton is sown, and cassava may also be planted. As the cotton gives no crop in the first season, and as no cultivation is given except the preparatory hoeing when seed is sown, it has to compete with weeds and secondary forest growth (Sampson 1930). The maintenance of fertility by bush regeneration requires from eight to ten years, but the demand for land leads to a lessened period of bush fallow and consequently to decreased fertility, to which erosion, in a country of so heavy and concentrated a rainfall, also contributes. The problem confronting the agricultural department is to substitute some other method of maintaining or increasing fertility. In the absence of animal husbandry some form of green manuring appears to be required. Experiments at Njala have shown *Calopogonium mucunoides* to be best, but in view of the difficulty of inducing natives to grow green manure crops which provide food for neither man nor beast, experiments with pigeon peas and *Centrosema pubescens* are being made (Sierra Leone 1936, *D.R.*). Possible crop rotations and methods of maintaining fertility are discussed by Sampson (1930).

In Eastern Africa similar work is progressing. For example, in Nyasaland it has been shown at the experimental station at Zomba that land which is typical of large areas can be kept permanently fertile by means of suitable crop rotation combined with manuring and terracing of sloping land to prevent erosion. Work

is also directed towards accelerating the regeneration process while the land is left fallow. Most of the methods employed fall under the heading of forestry rather than of agriculture, and have been mentioned in Chapter VII.

Uganda provides an example where wild grasses can be employed with benefit to restore fertility. Experiments have been in progress since 1932 at Bukalasa with planting grasses, particularly the larger kinds such as elephant grass (*Pennisetum purpureum*), as soon as cultivated land is vacated. The results to date show that the rest period, which is usually about ten years, can be reduced to four years by this means. Similar studies have been started at Serere and Ngetta and are also favourable. The introduction of green manures and other methods foreign to native practice has met with little success, but the use of grasses is regarded as a most promising improvement to a system which already exists and which has stood the test of time under the local conditions of soil and climate. The Director has pointed out with some justice that the natural regenerators of soil throughout the world are either grass or forest, and that nature herself does not employ legumes for the purpose, except in a minority compared with other plants. He considers that the attention attracted to legumes as a result of scientific work on their nitrogenous properties has led to neglect of the possibilities of utilizing the ordinary processes of nature.

MIXED CROPPING

Mixed cropping, which consists of growing more than one crop on the same soil at the same time, is practised by natives in many places, and has received attention from agriculturalists in several territories. One advantage of the system is that it may enable an export crop to be grown without unduly extending the area of cultivation or increasing the amount of labour involved in tilling. The Nigerian agricultural department has found that the native methods of growing Ishan cotton and other cottons of this type as a mixed crop are more profitable than growing it as a pure crop.

In the yam-growing districts in the Northern Territories of the Gold Coast, particularly around Tamale, a similar practice is almost universal. Definite combinations of crops grown in the same year have been evolved to suit the particular types of soil.

The native plants his crops at successive intervals, in accordance with the length of the growing period of each, so that the crops are not necessarily harvested in the rotation in which they were planted. Also ripening periods vary, so that the labour of harvesting is well distributed. Trials carried out at Tamale in 1929 showed that one acre of land under mixed cropping yielded the same quantity of produce as nearly two and a half acres cultivated on the single crop system. It was therefore concluded provisionally that mixed cropping was the superior of the two methods, but further trials were considered necessary. The interplanting of groundnuts with cotton, tried at Ngetta in Uganda since 1934, gave similar results, provided the right proportions of groundnuts and seasons for planting were adhered to (Uganda 1936, *D.R.*). In the Gambia, however, trial interplantings of groundnuts and bulrush millet (*Pennisetum typhoides*) and groundnuts and Guinea corn, undertaken during 1934 at Wuli, did not give a sufficient yield of groundnuts to warrant their cultivation by this method (Gambia 1934, D.R., p. 10). It is possible, however, that experiments on these lines may yet prove successful, since in Madras where a short-season bulrush millet is used, in which groundnuts are underplanted, little interference is caused, provided the millet is harvested before the fruit has covered the ground. Mixed cropping is usually looked upon as an insurance against adverse seasons; some parts of the mixture may succeed or fail according to the vagaries of the season. Difficulties may arise from lack of water when two crops are competing on the same soil, so research is advisable to find out to what extent and in what form mixed cropping should be developed in any area.

COMPOSTING

Owing to climatic conditions, for example in Northern Nigeria, the turning in of green manures is not always practicable, since the ground requires to be moist and the crop succulent. If the crop is too dry it does not decompose and fixed nitrogen in the soil may be deficient; if too woody, the bacteria which break down the cellulose exhaust the soil of nitrogen which they need for their sustenance. For this reason the composting of vegetable waste materials or even of crops, such as elephant grass, grown for this

special purpose, may come to be widely used as a substitute for green manuring. Composting consists in using fungi and bacteria to break down suitable mixtures of vegetable and animal wastes. In the so-called Indore process, by arranging these mixtures in the proper way, and by watering and turning them, to supply moisture and air, the waste materials are transformed in about ninety days into a finely divided humus rich in the foods required by growing crops. The process can be adapted to climate by manufacture either in shallow pits or low heaps. No buildings or expensive plant are required, nor are pure cultures of the organisms concerned necessary, as they occur everywhere. 'Compost making by rule of thumb is as old as agriculture itself.' (Ministry of Agriculture 1937.) On this basis it has been used for centuries by the Chinese, who have evolved an intensive system of agriculture to meet a population density unparalleled in Europe (Hall 1936). Much of the pioneer work of elucidating the underlying scientific principles was done at Rothamsted. The application of composting to African agriculture was directly due to the remarkable success obtained by Sir Albert Howard at the Institute of Plant Industry, Indore. Confronted with the problem of obtaining a continuous and adequate supply of manure for the small Indian cultivator, in a region where cattle dung is generally used as fuel, he evolved the so-called Indore method.

Howard and Wad (1931) have described the various processes in detail in their volume on the waste products of agriculture, and Howard (1935) has described the applications of the Indore method to conditions in Africa and in other parts of the world. The difficulty with the average native cultivator in Africa is that, so long as shifting cultivation is possible, he will not take the trouble to carry out the regular watering and turning required in the Indore process; moreover, in many areas the lack of water renders the operations difficult or impossible. The method has, therefore, had to be modified to suit local conditions. Experiments with modifications of the Indore process were already in progress during 1933 at each of the local Native Council seed farms in Kenya (Kenya 1933, *D.R.*, p. 109), and the department of agriculture issued a bulletin on the subject (Beckley 1934b). An interesting experiment was carried out in 1935 at Embu in Kenya by Mr.

H. E. Lambert and is described by Howard (1935). The original technique evolved at Indore was simplified for explanation to the illiterate African. The materials were not prepared, but were simply stacked near the pits so that they were ready to hand when manufacture began. By a simple rotational system every operation required was repeated on the same day of the week, and the results were excellent. Campaigns for making village compost now occupy much of the time of all field officers. In 1936, in the Central Provinces alone, where cattle for the most part are not kept on the holding, some 100,000 compost pits had been brought into use (Kenya 1936, *D.R.*, Pt. I, p. 88). In Nyasaland also methods of composting, based on the Indore process, have been evolved; the principal object being in this case to provide a method of making soil fertile for finger millet and other crops, as an alternative to the chitemene system. It is claimed that details are now sufficiently worked out for the composting to be introduced in native areas, and through the agency of demonstrators progress has been recorded (Nyasaland 1935, *D.R.*).

In the West African colonies various trials have been made with composting, and opinions differ about its efficiency. In Nigeria results attained by the agricultural department have not been encouraging, although experiments so far have been on a comparatively small scale, mostly at Samaru in the Northern Provinces. It is claimed that there is no proof yet that the compost makes a better fertilizing agent than the same amount of animal manure and ash from the same quantity of plant material when applied directly to the land. On the other hand, an experiment by the research branch of the forestry department has been encouraging: waste material from nursery weedings and grass cleanings was used, with ammonium sulphate and lime as agents to produce the 'activator'. Both chemical analysis and nursery tests proved satisfactory (Nigeria, Agric., 1935, *D.R.*, p. 114). In the Gold Coast trials by the department of animal health at Pong-Tamale have led to the conclusion that the process is not economic, but the agricultural department have a more favourable opinion of its value when modified for local conditions, and have pointed out its advantages to farmers (Gold Coast, Agriculture, 1935, pp. 229–30). It appears however, that none have so far adopted it.

MIXED FARMING

In all parts of Africa where cattle can be kept, the use of animal manure, whether or not combined with vegetable materials into compost, clearly offers great opportunities for the development of a balanced agriculture based on problems involved in settled cultivation. The combination of animal husbandry with cultivation at the same time opens the way for that revolutionary change, the replacement of the hoe by the plough drawn by cattle. It must, however, be borne in mind that the basis of mixed farming is the use of the manure supplied by cattle to maintain soil fertility. Thus the area to be farmed ought to be limited by the amount of manure available, rather than by the area that can be ploughed. This introduction of mixed farming may be illustrated from experience in Northern Nigeria.

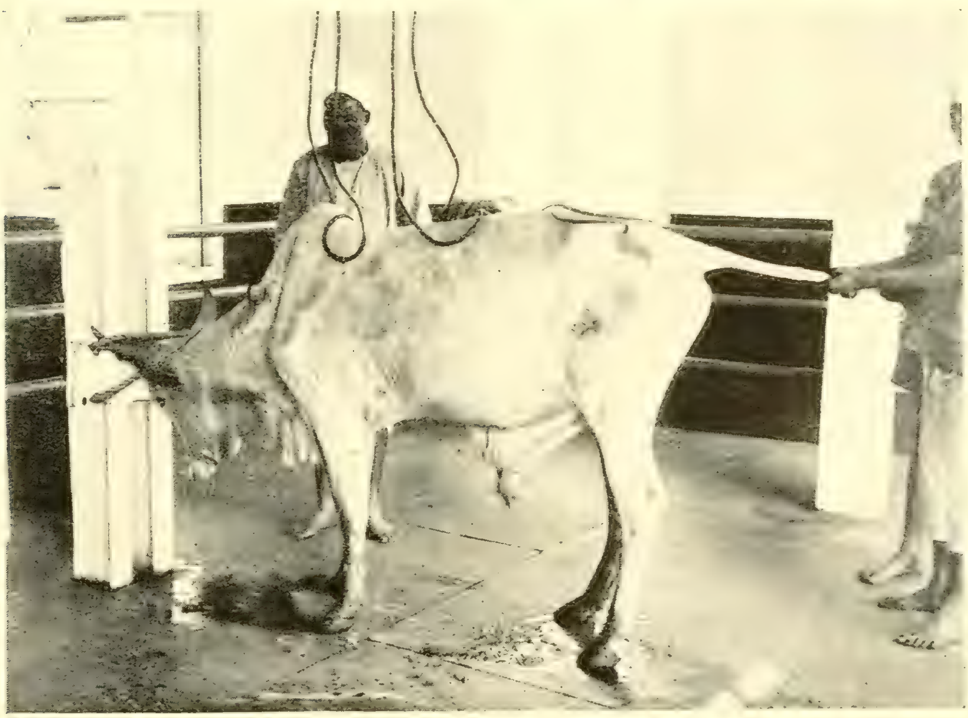
In this region the whole agricultural system depends on the short rainy season. Irrigation appears to be impracticable, except on a small scale, and it has been mentioned that green manure cannot be used. It is suspected that phosphate deficiency is the most important cause of infertility. Imported super-phosphates have caused big increases of crops at experimental stations, but are far too expensive for general use. Phosphates from local deposits have been tried with satisfactory results in the Southern Provinces, but they are not sufficiently soluble to be of much use in the dry northern climate. All conclusions, therefore, point to the use of animal manure, and hence the agricultural department has concentrated on the development of systems of mixed farming. The stock farm at Shika near Zaria is devoted largely to producing animals to serve the dual purposes of draft combined with high milking capacity; the interesting experiments in breeding carried out there and elsewhere in West Africa are mentioned later. A number of suitable animals have been distributed to native farmers, particularly in the region around Kano, each farmer receiving a loan of from £5 to £7 from the Native Administration towards the purchase of oxen and farming implements, such as ploughs and cultivators. This system was instituted in 1933, since when the number of mixed farmers has doubled each year. In 1936 there were 680 working successfully, and it was estimated that in 1937 the number would have increased to at least 1,200, and that in

another five years it should be 10,000, provided sufficient suitable cattle are available. Each man with two bullocks can plough ten to fourteen acres in the same time that he could cultivate three acres with the hoe. This extension of cultivation is largely devoted to the production of cotton, which, it is estimated, will increase by 10,000 bales in the next five years; experiments on suitable cottons have been conducted by the Empire Cotton Growing Corporation at their seed farm at Daudawa.

Mixed farming has been made possible only since the veterinary department has succeeded in controlling rinderpest and other major cattle diseases by inoculation processes. Trypanosomiasis still renders stock raising uneconomic in many areas, but, in so far as the extension of mixed farming results in concentration of population in permanent settlements, it will reduce not only the man-fly contact, but also the cattle-fly contact, as mentioned in Chapter X. With regard to the efficacy of farmyard manure in increasing fertility, the work of Hartley and Greenwood (1933), mentioned in Chapter V, may be referred to once again as showing the remarkably increased yields in the arid climate of Northern Nigeria, which result from small applications.

The possibility of mixed farming in the forested southern parts of Nigeria has not yet been the subject of serious inquiry, but the presence of herds of shorthorn cattle which, though diminutive in size, apparently show complete resistance to local strains of trypanosomiasis, is taken by some people to indicate the possibility of development along similar lines.

In the Gold Coast experiments with mixed farming in the Northern Territories are progressing at Tamale, and suitable animals are being produced by the Government stock farm at Pong-Tamale in charge of the department of animal health. At Zuarungu near the French frontier efforts have been made to persuade native farmers to take up the practice, but so far little success has been achieved owing to the lack of any organization for the advance of funds for the purchase of animals and implements. The large pastoral areas of the Accra plains near the coast, where a survey of possibilities in animal husbandry has recently been made by Mr. Fulton of the department of animal health, also offer opportunities for mixed farming now that animal dis-



Above: MIXED FARMING

Training oxen to the plough in the Northern Territories of the Gold Coast

Below: VETERINARY WORK

Making anti-rinderpest serum from Zebus bulls at Vom, the veterinary headquarters of Nigeria

eases are fairly well under control. In the French Sudan mixed farming has been introduced in a number of districts. Good progress is also being made in the substitution of the plough for the hoe; for example, in the *cercle* of Ségou there were said to be more than 1,000 ploughs at work in 1936; a figure which compares very favourably with that for Northern Nigeria. It is claimed that the native oxen of the Sudan are easily trained for draft purposes.

In East Africa, similar efforts are being made in Tanganyika. In the settlements made on land reclaimed from the tsetse fly, the area allotted to each cultivator is large enough to accommodate livestock sufficient for its working on the lines indicated by the agricultural department, and to keep an area of bush land reserved to counter erosion by rain and wind. This reserve area is maintained along the contour wherever possible. In densely settled areas attempts are made to incorporate the plots abandoned after cultivation with neighbouring plots which are still under cultivation. The object of this is to increase the size of the holdings and to oblige the young men to venture on to new land at the margins of the settlements rather than to occupy the vacated land before there has been time for proper soil regeneration. In Uganda again, the fact that some 15,000 ox-drawn ploughs were in use in the Eastern and Northern Provinces by 1933, since when the number has increased materially, indicates that mixed farming has come to stay. Likewise in the native protectorates of Southern Africa the chief change in agriculture has been the substitution of the plough for the hoe. Sir A. W. Pim (Swaziland 1932) notes that 5,989 ploughs were in use in Swaziland during 1931, since when the number has greatly increased.

In some parts of Africa native farmers reject animal manure, when it is obtainable, on the score that weeds and pests result from its use. In this connection the claim that composting by the Indore process destroys weed seeds by the heat engendered in the heap may point to a method of preserving farmyard manure with this end in view. It is evident that instruction in correct treatment of farmyard manure will be necessary as it becomes more available. At present the system of kraaling stock in animal husbandry wastes practically all the manure, and consequently it is often

suggested that much could be saved for use on arable land if a simple form of paddocking could be substituted for kraaling. The former method is certainly the more satisfactory on European estates, and is being adopted rapidly, but in native areas the cost of fencing is a serious obstacle to its introduction. Moreover, kraaling can conserve manure if suitable methods are employed, whereas paddocking can waste it in a dry climate, where the valuable nitrogen is lost when manure is exposed and the organic matter is open to attack from termites.

Cultivated land can also be manured directly by tethering or penning cattle on the fallow fields. This is practised to a small extent in some parts of Africa, for example in the Gambia, and it is a common method in India, especially when combined with folding sheep. In Tanganyika the housing of livestock as a means of production of high quality manure on the lines of the existing practices of the Chagga and the Ukara peoples is recommended by the agricultural department, whose estimate of its value is supported by their own experiences on stock farms.

Wherever mixed farming is practised it is necessary to decide what products are to be developed for export. In Eastern Africa it appears that for a long while to come the plant production will provide all the export, the cattle being regarded primarily as fertilizing agents. Thus cattle and coffee farming can be combined. At the same time there may be opportunities for the exporting of dairy products and in some places the wool industry is no doubt capable of extension. The export of beef may never be practicable, but its production for local consumption by the million natives in East Africa must have possibilities. At present, however, the experiment at Mwanza, as mentioned in Chapter XIV, seems to show that there is little local demand.

With the slaughter of stock, blood and bone-meal become available as fertilizing material. Preliminary experiments with such material from the Mwanza meat factory have been made on partly exhausted land in the Lake Province of Tanganyika. The results were similar to those with farmyard manure and showed marked increase in yields with very small applications. The agricultural department has, however, advised against the deliberate production of fertilizers from the desiccated remains of animals

slaughtered for the purpose, since it is held that a live animal producing manure daily from crop residues is a better fertilizing agent than the same animal dead, dried, and pulverized. Where stock must be killed, the cultivator will eat the flesh, and his added energy will do more for the land than the sacrifice of the ox to a desiccator.

In recommending any improvements to native agriculturalists it has to be remembered that every native practice has become closely adapted to special local conditions. In certain areas, moreover, the methods which have been employed for many generations, could scarcely be improved. This is strikingly shown by the practices of the Chagga of Kilimanjaro and the inhabitants of Ukara Island situated in the south-east part of Lake Victoria. The Ukara agriculture has been described by Thornton and Rounce (1936). The natives have become so concentrated that there is no opportunity for shifting cultivation, even if the country was originally suitable for it, but the arable part of the island is under continual cultivation, and a complicated system of crop rotation has been evolved, including the growth and digging in of green manures. The cattle are largely stall-fed on forage specially grown for the purpose, and are housed in special compartments of the natives' own houses; their manure is transported to different parts of the cultivated land in turn. When the cattle are turned out to graze on the grasslands in the interior of the island, they are muzzled and led through the cultivated fields. Soil erosion is counteracted by earth ridges and stone walls along contours, by pit cultivation on the hillsides and even by stands of trees. Even such intensive methods of farming do not suffice for the increasing population, and young men are continually emigrating. When they settle in islands near by or on the mainland where there is less pressure of population, they discard the practices to which they were brought up in favour of the easier methods of their new neighbours. Ukara Island is peculiarly interesting, since the indigenous methods there differ but little from the improved methods which agricultural and administrative officers are attempting to impress upon natives in other parts of Tanganyika. But it must be remembered that the system depends on the inexhaustible water-supplies. From an anthropological point of view

it bears witness to the inventive ability of natives under the pressure of environment. The Ukara example is not entirely unique, and as knowledge of native agriculture improves, no doubt many similar examples will come to light. Mrs. Gore Brown, for instance, found on Chilubi Island in Lake Bangweulu a very long cycle of crop rotation which also appears to be an adaptation to abnormal conditions of close settlement, and the system of settled agriculture near Kano in Northern Nigeria provides another example.

CO-OPERATIVE SOCIETIES AND AGRICULTURAL POLICY

An agency which offers great possibilities for the improvement of native agriculture is the co-operative society. This provides a medium of education which can be applied as soon as there are a few educated Africans with organizing capacity scattered amongst the population. Such societies have been instituted under guidance from agricultural departments in a number of British territories, and have assisted especially in the grading and marketing of produce, transport, and pooling of food resources. In the future, no doubt, other aspects of agriculture, such as selection and distribution of seed and the breeding of stock, may also be undertaken on a co-operative basis, but it is perhaps premature to apply such ideas until more is known of the scientific principles to be adopted, and until the breeding of stock or selection of seed suitable to particular areas can be reduced to a definite code of rules. Then is the time to broadcast the knowledge gained and to extend the use of the best kinds through a co-operative system.

Mr. C. F. Strickland, after wide experience of the co-operative movement in India, has been forward in advocating its application to African peasantry. Quoting from him (*The Times*, 14th August 1934):

'Co-operative societies, for breeding of stock or selection of seed, for marketing of crops and the provision of water, will help the African towards improvement more than an infinity of argument with unorganized individuals, and it is fortunate that the African governments are turning towards co-operative methods.'

Other authorities hold, however, that the co-operative society

involves a wider departure from existing native organization than is supposed by its advocates, and that the authority of native chiefs is a more effective influence in the introduction of improved agricultural methods.

Whichever method is followed, the Native Administration, where one exists, is in a position to exert an influence on the cultivator, to supervise marketing and generally to see that satisfactory methods of cultivation are followed. In addition, in some territories, where non-natives hold land close to areas of native farming, planters' associations, designed for mutual assistance and aid can be helpful to their African neighbours. Such non-native associations are mentioned in a later section.

To build up an efficient co-operative society from primitive material is difficult, even where economic conditions are suitable, The members are called upon, at the outset, to learn new and possibly incomprehensible principles and regulations. Co-operation, far from being a method to get rich quickly without extra effort, consists in the patient application of high standards, both of agricultural and financial efficiency. In spite of these difficulties, however, marked success has been attained in several territories as detailed below.

The *Gold Coast*, where the cocoa industry is well developed and there are a comparatively large number of educated farmers, has seen the greatest advances in this direction. The formation of co-operative societies in the cacao-growing districts has been one of the chief aims of the agricultural department. The co-operative movement has been studied in detail by Professor C. Y. Shephard (1936) and is also described by Sir F. A. Stockdale (1936) in the report on his visit to Nigeria, the Gold Coast, and Sierra Leone, which gives a complete picture of many agricultural activities in these territories. In the Gold Coast credit organizations have not been as extensively developed as in other British territories and the policy has been 'to improve methods of preparation as a means of securing price discrimination' (Shephard 1936). The Co-operative Societies Ordinance was passed in 1931, and in spite of initial native apathy and mistrust, in the five years since then over four hundred societies have been formed with a total capital of £12,000. In the initial stages the work of secretary

and treasurer had to be done by agricultural officers, but most of the societies have now their own African secretaries and treasurers, who usually work under supervision from European members of the department of agriculture. Loans are advanced to the societies by government; for example, in 1935 the total sum advanced was about £6,000, all of which was repaid without trouble. Progress has also been made in organizing the producers of rice, coconuts, and cotton. The department claims to have proved that Africans of the Gold Coast can be persuaded to organize themselves for the co-operative solution of their problems.

In *Nigeria* a similar move to institute co-operative societies was started by the agricultural department, but so far only the marketing side of agriculture is included in their activities. For example, numerous cocoa societies, with membership varying from 20 to 200 have been established, and each maintains a store at its headquarters for the deposition of the crop from every member's plantation. In the area around Ibadan all the societies belong to a Marketing Union, which undertakes the sale, and after expenses have been deducted, proceeds are divided among the members in proportion to the size of their crops. Thereby the activities of the middleman, who formerly often bought the crop before harvesting, at a very low assessment, have been restricted, and the large exporting firms such as U.A.C. and John Holt can now obtain the crop direct from the producer. Each co-operative society is managed by a committee, of whom the secretary is usually the only literate member. A Registrar of Societies was appointed in 1933 and an ordinance for the registration of societies was made in February 1936, so that registration would give each society a legal status and would qualify it for supervision by the government. So far, however, there are few societies which are up to a standard sufficient to qualify them for registration. In Northern Nigeria the development of mixed farming, referred to above, is essentially dependent on the advance of money for the purchase of cattle, implements, etc., while the crop is marketed largely through the agency of the British Cotton Growing Association. The possibility of substituting a farmers' co-operative society for this system is discussed in the report of the co-operative officer for 1935–7 (Nigeria 1938).

In *Sierra Leone* there are good prospects for co-operative societies in the Scarcies rice area where the need for credit is already felt. One association of an administrative, rather than a co-operative type, has been instituted as an experiment, and an ordinance to establish societies has been proposed. Stockdale (1936) held that the introduction of a co-operative movement on a large scale would be premature.

In the palm oil districts of West Africa conditions are much more difficult for instituting societies, because the crop is obtained from so many owners of trees and in comparatively small quantities. The movement is afoot, however, in parts of Nigeria and in some cases producers have grouped together to purchase palm presses under common ownership.

In Eastern Africa the tendency has been to use the small political unit rather than the village as the basis of the co-operative society, a method which is open to criticism from those who hold that trade and administration should not be combined. From *Tanganyika* an administrative officer was sent to India in 1934 to study co-operative methods with a view to his appointment as registrar of the societies. The Kilimanjaro Native Co-operative Union markets the produce (coffee) of its members in bulk, and it has been proposed to form societies on the same lines as this organization in the tobacco districts of Songea and Biharamulo.

In the Bugishu district of *Uganda* measures have been taken to maintain the quality of coffee exported at a uniform high standard. Central pulping-stations have been built and each consignment is sent to a central factory at Bubulu, where it is properly dried, hulled, and graded. The scheme is controlled by the Native Administration with the ultimate object of encouraging the establishment of co-operative societies among the growers themselves. In Buganda associations have been formed to deal with cotton and other crops (Thomas and Scott 1935).

In the *French territories* of West and Equatorial Africa a system similar in some ways to co-operative societies has been evolved. In every district headquarters there is a local *Société de Prévoyance*, which is organized by the administrative officer in charge of the district with the assistance of a secretary-treasurer, but has also a council of natives chosen by the local assembly of chiefs. Sub-

scription from all the farmers in the district is compulsory, and is, in effect, an additional tax, the proceeds of which are devoted to local interests. The societies distribute seed, and organize marketing, and expensive machinery for oil presses or cotton ginneries is purchased with their funds. These societies have undoubtedly led to a marked improvement in native agriculture, but their compulsory character differentiates them from the British co-operatives where the voluntary nature of membership is regarded as essential.

The policy adopted for the improvement of native agriculture in the *Belgian Congo* consists in many areas in making compulsory the production of export crops such as cotton. In the initial stages agricultural instructors work among the population and a certain amount of coercion appears to be necessary to make each native farmer put a fixed area of his holding under the selected crop, but as soon as the natives have reaped a return for the produce the system runs on smoothly enough.

However desirable it may be from the sociological aspect to maintain tribal custom in agriculture as in other subjects, it is impossible to do so unless at the same time the economics of production can meet the demands of the world's markets. An instance of the conflict of opinion over the plantation as opposed to the peasant system of agriculture is afforded by Nigeria; it has been discussed by Buell (1928, Pt. I, pp. 768ff.). In this connection Dr. H. Martin Leake (1935) looks especially to Corporations or Chartered Companies to provide the solution. He points out that, to compete in the world market to-day, produce must be of the highest quality and carefully graded, so that a measure of technical control is indispensable. He argues that the system of peasant production with its small independent units, which is now favoured on sociological grounds, is ill adapted for the exercise of this control. In official policy hitherto the sociological view has dominated, but the pressure of circumstances is forcing the adoption of more and more control, with the result that colonial governments are being driven to administer two different and somewhat antagonistic policies. To meet this dilemma he proposes the creation of corporations having limited jurisdiction over defined areas, and he suggests that not only would colonial governments be in a better position to see that the essentials of the social structure were re-

tained as far as is compatible with the fundamental laws of production, than if they themselves were the authors of the restrictive measures, but adequate technical control would be provided, since it would be charged against the industry and not against the community.

Dr. Leake quotes the two examples of development by corporations within the Empire in support of his proposals, the Colonial Sugar Refining Company in Fiji and the Sudan Plantations Syndicate in the Sudan, and uses these to support his argument that a competitive product can be raised by corporations with profit. Both have found it economically profitable to employ a supervisory staff such as no government could entertain. In the case of the Sudan Plantations Syndicate one officer is employed for each 5,000 acres. In addition to these advantages, he considers that such corporations would produce a source of employment for the educated native, who, in regions which attempt to maintain the native social organization, have no future except in the law or government service.

Not all authorities share these views. There is a strong body of opinion, that schemes of this nature are not entirely beneficial, and may even prove disastrous to native life in the regions concerned. The development of export crops at the expense of native food crops, which characterizes the company system, can easily lead to an unbalanced system of agriculture. An alternative method of obtaining the requisite measure of technical control in agricultural production is a government run on strictly business lines, but this naturally has its own disadvantages. It is perhaps appropriate here to refer to the success of the Dutch in Java, where the government exercises a substantial control over native activities in connection with sugar-growing, and also to the great experiment of the Office du Niger in the French Sudan, an undertaking which is to be organized on the corporation basis, though the large capital expenditure involved is drawn mainly from government funds.

AGRICULTURAL EDUCATION OF AFRICANS

Once the best methods of agriculture in any set of conditions are proved by research, and suitable crops for each district bred and

made available for dispersal, all improvement in native agriculture, both for subsistence and for export, must come through the medium of education, both of children in schools and of adults through the medium of agricultural departments. The discussion of African educational systems as a whole, falls outside the scope of this volume, but a few notes may be given on certain aspects of agricultural education, namely general education in agriculture designed to improve the technique of African farmers, and special education designed to produce expert native agriculturalists.

As a means of promoting the general improvement of farming, there is a hope that school teaching in agriculture may prove effective in some areas, but more faith is usually placed in the development of demonstration plots in which adult farmers may see the results, combined with the employment of African demonstrators as part of the organization of each agricultural department. In some territories, for example Uganda, it is considered that more still can be done by personal advice given to chiefs by agricultural officers. With the majority of African natives the effort required to break down tradition is enormous. Therefore the agricultural demonstrator must be quite sure of the value of the methods which he tries to substitute, since failure in a trial area creates a widespread prejudice against other innovations.

Demonstration plots are now established as part of the organization of agricultural departments in nearly every territory, and in some there have been big developments in recent years. For example, in Southern Rhodesia the Department of Native Development inaugurated in 1927 a scheme for the special training of native agricultural demonstrators, and already results have been fruitful, as described by Alvord (1930). A three-year course is taken at special government institutions, after which the students are absorbed into the department, and work mostly in the native reserves. There are now some forty-five of these trained men and a big increase in the number of demonstration plots has been possible. The Lake Province of Tanganyika may be mentioned as the site of an experiment in the so-called ideal native holdings. The individual native holdings are from ten to twenty-five acres in extent, and are all supervised by European agricultural assistants.

The improvement in crops and the standard of living of the holders is said to serve as a better example to neighbouring farmers than the usual demonstration plots attached to government agricultural stations.

In Uganda a special endeavour is made to give an agricultural bias to the ordinary school curriculum by providing prospective teachers with a two to three months' agricultural training before they take charge of schools. This takes place at the agricultural stations at Bukalasa and Serere. One month courses are provided for selected groups of native chiefs in order to further propaganda work, and the more promising members of the junior native staff are also given a short training from time to time. Lastly, a smallholder's two-year course is on trial at both stations. In this groups of about six young men of the superior peasant type live and work on model holdings of about twelve acres under conditions which they can be expected to maintain for themselves when their training is finished. When the students return to their own land they are assisted by the Native Administration to purchase cattle, ploughs, doors, and windows, to enable them to set up for themselves as nearly as possible an exact copy of the holding they helped to work. Arrangements are made for keeping in touch with each student after he has left the station. Agricultural training for prospective school teachers is stressed also in West Africa; in Nigeria the training schools at Toro in the Plateau Province, at Ibadan, and elsewhere are important in this respect. In the Gold Coast, Hunter Hostel, at Kumasi, is used for two months' training for native farmers, after which they are expected to return to the land and employ improved methods.

For the production of native agriculturalists of the type designed to form auxiliary staff in agricultural departments, several stages are necessary. First comes the normal native education, and here it is important to note the introduction of some biological teaching in recent years. Concerning the higher education which follows, results are anxiously awaited from the recent ventures in several territories, in particular Achimota College in the Gold Coast, Makerere in Uganda, and Yaba College near Lagos in Nigeria. These centres are reasonably well provided with facilities for training in scientific subjects and the staff have begun to publish simple

books on native plants, animals, methods of agriculture, arts and crafts, etc.

In addition to these centres of higher education which it is hoped to develop in course of time to a University standard, several territories have their own agricultural colleges attached to the agricultural departments for the purpose of providing specialized training for prospective government service. Thus in Uganda, after three years at Makerere College, agricultural students are taken into the department of agriculture for two years' special training. Nine such students were absorbed by the department in 1937 as native agricultural assistants (on probation). For the special training there is a Superintendent of Agricultural Education assisted by three full-time agricultural officers, who are seconded for one or more tours at a time for the purpose. On the veterinary side there is a small school at the veterinary laboratory, providing a three-year course for boys who have taken their pre-science course of two years at Makerere. These are intended solely as native veterinary assistants in Government service, to replace the more or less untrained assistants usually employed and European subordinate staff.

In the Southern Provinces of Nigeria there is an agricultural college at Ibadan to which pupils go after two years at the Higher College at Yaba. The research staff of the Ibadan laboratories assist in the teaching. In the Northern Provinces of Nigeria the subordinate staff of the agricultural department is trained at the Samaru Farm School, being selected from students passing out of the Higher College at Katsina. Each pupil has a holding of four acres, and also has to work on the experimental plots. The organization for specialized agricultural education in the Gold Coast is undergoing some changes, since Cadbury Hall at Kumasi, the former training centre for prospective service in the agricultural department, was closed down during the depression years. Meanwhile developments in agriculture at Achimota College have taken place and arrangements are now going forward to establish a settlement of highly trained agriculturalists after completing their courses at the College. An estate has been acquired, and it is hoped to develop the research side of agriculture as well as to demonstrate the value of higher

education among Africans who will subsequently return to the land.

In Sierra Leone the African instructors of the agricultural department were formerly men with a high degree of education. After a period of employment of farmers, with little education, it is proposed to return to the old system. The instructors are to have a two-year agricultural course at Njala, followed by two years on an experimental farm before beginning work.

In French West Africa agricultural officers are appointed to tour given districts, in which they instruct native farmers and advise the *Sociétés de Prévoyance*, and they also supervise the demonstration farms in the villages. Each school has a small farm attached to it, on which the pupils work. At Bamako in the French Sudan a system of higher education in veterinary work has been developed to provide African veterinarians for the stock country of the Sudan and Guinea. The staff of the veterinary school, which has been in existence for fifteen years, consists of an African *Chef du Service* as director and a veterinary surgeon. In addition, three medical officers from Bamako, an officer from the agricultural service, a chemist from the medical service and an administrative officer assist in the teaching. There are fifty students who take a three-year course, and then obtain a diploma before entering the Government service. Five or ten students are turned out each year. The African subordinates for the veterinary service take a two-month course before beginning field work.

PLANT INDUSTRY OF NON-NATIVES

More than 90 per cent of European farmers in Africa south ot the Sahara reside in the Union, Southern Rhodesia, and the Kenya highlands, and in the last named considerable areas of land are also owned by Indian immigrants. In these areas the greater part of the good agricultural and pastoral land is farmed by non-natives. European settlement has taken place also in small parts of Northern Rhodesia, Nyasaland, especially the extreme north and south of the territory, Tanganyika, especially the southern highlands, and Uganda, where a few European estates are situated about the foothills of Mt. Ruwenzori. In

Western Africa there is practically no European-owned land in British territories, except a few plantations in the Cameroons, most of which passed back into German hands after the war. French Guinea is the main centre of European agriculture in French West Africa, and the French Cameroons include some very large plantations, which were taken up under the German administration. Large plantations are established also in parts of the Belgian Congo.

The distinction between native and non-native cultivation does not depend now on the kind of crops grown, but mainly on the difference between the large-scale organization of capital production, and the small unorganized units of peasant cultivation. In many parts of Africa, especially where systems of individual land tenure are replacing the former widespread communal tenure, the size of some native plantations has increased to a point where conditions approach those on European estates. The larger cacao plantations of the Gold Coast, the coffee plantations of northern Tanganyika and parts of the Uganda cotton areas may be instanced as examples.

The alienated areas in Africa are not immune from some of the troubles resulting from defective methods of cultivation which have been described in connection with the native areas. Europeans also have sometimes worked land until crops can no longer be raised on it, even with the aid of fertilizers, and then abandoned it to the ravages of soil erosion. In this the European may be even more destructive than the native since he works on a larger scale and aims at keeping a cleared area permanently under crops. A large expanse of ploughed land enables surface run-off to gather volume and force, and, unless adequate steps are taken to counteract this, erosion can be and frequently is very severe. In Nyasaland, for example, in former times many of the European tobacco areas have been reduced from a loam to a sandy loam by the fact that ridges and furrows for tobacco cultivation have not followed the contour but frequently were aligned steeply downhill. The result has been that the finer particles of soil have been washed away by surface run-off, and the coarser sand has been left behind. European cultivation also is usually cleaner from weeds than that of the natives and, therefore, is more liable to wash, as there are only

the roots of the crop to hold the soil. It is certainly regrettable that some European-owned land in Africa is worked on a principle which is not worthy to be designated as farming, but can only be termed soil exploitation. On the other hand, many estates could be mentioned which apply the best principles in soil conservation and fertilization, and which not only act as experimental centres where new ideas can be put to the test, but serve also as examples to native cultivators in the surrounding country.

Apart from research on crops, which has been considered above, the problem of cultivation on European-owned estates is mainly that of maintaining fertility in spite of continual or frequent cropping. The solution seems to depend on two lines of activity—conserving the soil and using fertilizers. The first of these has been considered in some detail in discussing native cultivation, and many of the methods mentioned, such as terracing and contour ridging, establishing suitable plants on ridges along contours to hold back soil-wash, and maintaining a vegetal cover on the soil during periods of rain, can be applied even more easily on European estates than on native small holdings.

The use of fertilizers, however, is more important in connection with European estates where it is recognized to be essential. The major problem is to find a fertilizer which the cost of freight from Europe will not make prohibitive. This is essentially an economic rather than a scientific question, but the following notes may indicate the bare outlines of the problem.

At present the local fertilizer supplies are almost negligible: animal manure is insufficient except in a very small area, and mineral phosphatic deposits are lacking except in South Africa. There is a movement to manufacture bone-meal manure and fish manure as by-products of meat factories and fishing industries, and if the government meat factories are inaugurated as part of the campaign against the overgrazing trouble, there should be no difficulty in disposing of any quantity of fertilizers, if they can be produced cheaply. Another way of obtaining bone is the wide-scale collection of wild and domestic animal remains. In India the organized collection of bones has given rise to a considerable export trade. In Africa where many of the heavily stocked game and cattle areas are littered with skeletons, bone-meal factories

might obtain considerable supplies cheaply for some time to come.

The most hopeful outlook for making manure available on estates in Eastern Africa, seems to be the utilization of waste products of agriculture by the Indore process (*see* pp. 386–388). This has been tried in the tea, coffee, maize, sisal, and other plantation industries of Kenya and Tanganyika. One drawback is that the original method was devised for peasant cultivators in India, and when tried on a large scale, only those who practise mixed farming are able to obtain sufficient animal waste to be mixed with the vegetable material. This has been pointed out by Mr. V. A. Beckley, the Kenya agricultural chemist (1934a and b). Attempts have been made by Major E. S. Grogan at the Kingatori Estate near Kiambu in Kenya, to work out a cycle which will be independent of the animal link by means of using a fungus. The high lime and phosphate content of the soil and the presence of quick-growing indigenous legumes in this area will, it is hoped, make such a method practicable. Another disadvantage is that the arable soils in many parts of Kenya are definitely acid, whereas at Indore they are alkaline and carry a fair amount of calcium carbonate. Therefore in the original process soil was added to neutralize acids produced in manufacturing the compost, but in Kenya the addition of some base-supplying mineral such as rock-phosphate seems to be essential. In spite of these difficulties, a modified process is being evolved in Kenya, and the results are so far encouraging (Beckley 1934a).

Another application of the Indore process was made in Kenya in 1934–5, when a factory owned by the Express Transport Company was started at Nairobi for converting town wastes such as bone, horn, and hoof residues, animal manure, cotton seeds, chaff, wood, and tannery waste into manure. When necessary, the materials were finely ground before being mechanically mixed, and then were composted in pits according to the Indore process. In ninety days a humus was obtained, and produced excellent results on controlled experimental plots of flowers, vegetables, maize, grassland, and coffee. The oxygen supply presents difficulties here, and the use of compressed air was suggested by Sir Albert Howard (1935).

At the Abercorn agricultural station in Northern Rhodesia the

original process was adapted to local conditions, and in 1934 had become part of the normal routine (Northern Rhodesia 1934, *D.R.*). Tests on the compost carried out at Amani showed a deficiency of nitrogen and phosphoric acid, and it was thought that subsequent analyses might point to a revision of manufacturing methods. Since the heat occasioned by the composting process normally kills the seeds of weeds, the resulting material has an added advantage over farmyard manure. Experiments have also been carried out at the Morogoro experimental station in Tanganyika. The materials used included khus-khus grass, maize and sorghum stover and cotton seed (Tanganyika, Agriculture, 1934, *D.R.*). In Uganda, which is geographically situated so far inland that the cost of importing artificial fertilizers is prohibitive, a committee is endeavouring to find some practical method of utilizing the large quantities of cotton seed which hitherto have been destroyed at ginneries too far from a railhead to make export profitable. The seeds are so rich in oil that some local use must be found for the oil if the remainder of the seed is to be turned into compost, or alternatively it is suggested that the whole cotton seed would be more use if converted into feed-cake for stock. Meanwhile on European-owned estates in Uganda the maintenance of fertility seems to have been ensured for annual crops by suitable rest periods and sensible rotations. For coffee, grass mulch has solved the problem in areas where supplies can be obtained within reasonable distance, and there is always the possibility of combining cattle raising with coffee culture, as adopted with success on one estate. In Nyasaland the Tobacco Association has a special fertilizers sub-committee. Compost is already prepared on a considerable scale at Zomba (Nyasaland 1936, *D.R.*).

Fertilizers cannot be produced from local materials in sufficient quantity for use on the scale which the soil requires, and the European farming community in East Africa must continue to depend on imported fertilizers, especially from the phosphatic deposits of North Africa.

Before 1926, when Sir John Orr's report drew attention to the mineral deficiencies of the soils and pastures of the Kenya highlands, the import of fertilizers to Kenya was negligible. From 1927 to 1929 they amounted to the total of 2,000 tons. Almost all

of this was used for plantations of coffee, the only crop which at present commands a price sufficient to cover the cost of the fertilizer. The insufficiency of these quantities are shown by comparison with the following figures for two of the Dominions. New Zealand in 1927–30 imported 269,000 tons annually (94 per cent. phosphatic), and South Africa in the same period imported 234,000 tons annually (73 per cent phosphatic) (Speller 1931). In spite of this considerable import and the presence of local phosphatic deposits, it is generally agreed that the supplies of fertilizers in South Africa are in no way equal to her requirements. This is another argument for the development of stock-raising in parts of the Union where maize cultivation is reducing fertility of the soil. This subject has been discussed above on pp. 305 and 306.

Co-operative organizations have become popular among European farmers throughout Africa in recent years, a movement which has at the same time opened the way for the native co-operative systems discussed above. The farmers' associations organized in all settled areas, have been of great assistance, especially in marketing and distribution of seed. In certain cases the number of co-operative associations has grown to so great an extent that central control has become necessary. Thus in South Africa a Co-operative Commission, appointed by the Union Government in July 1933, showed that there were then 388 organizations. Efforts were being made to establish a central body to control the societies, but development had been retarded by the lack of suitable officials, and opposition to the movement had been shown by traders. In Southern Rhodesia the report of the Land Bank for 1935 mentions eight co-operative societies or companies.

In Northern Rhodesia an interesting development of the co-operative spirit is the locust insurance scheme of the Chisamba Farmers' Association. The total losses due to locusts are shared by the entire district, so that the possibility of the ruin of any individual has become remote. During the depression years there can be no doubt that many farmers were saved by the co-operative organization; for example, in the same territory a society regularly handles about 80 per cent of the settlers' maize crop and in 1933, exported 70,000 bags of grain at a heavy loss. In Kenya the well-known Farmers' Association offers many facilities for the best dis-

posal of crops, and this has been taken advantage of by settlers in the Northern Province of Tanganyika where an association was formed in 1935 for the purpose; three-quarters of the coffee crop were, in fact, sold forward in that year on the basis of the previous year's samples (Tanganyika, Agriculture, 1935, *D.R.*). These and similar activities in all settled areas relate to the economics rather than the science of non-native farming, and the examples are cited merely to instance the kind of way in which co-operation can assist the industry.

CHAPTER XIV

ANIMAL INDUSTRY

INTRODUCTION

It has been pointed out in previous chapters that the plant and animal industries cannot be treated separately. Accordingly, the sections on mixed farming, education, and the fertilizer problem in the last chapter must be borne in mind when considering animal industry. The subjects dealt with in this chapter include the characters of African stock, the possibility of improving the breeds, the effects of overgrazing, the diseases from which the animals suffer, and subsidiary topics such as hides and skins and the preservation of meat for market. A few general matters, however, must first be mentioned before these questions are discussed.

The opinion is sometimes expressed that the future prosperity of all the drier parts of Africa lies in pastoral farming rather than in agriculture. This extreme view has few supporters, since trade statistics show that animal products constitute a small proportion of the whole exports and in the internal economy crops play far the greater part. Nevertheless, livestock is the mainstay of existence of many African tribes to-day, and is likely to remain so for several generations to come. In the future, moreover, animals and their products are likely to take a much more important place in internal trade as a more commercial attitude is adopted by the natives towards their stock. Thus there are clearly possibilities for the development of an animal industry, perhaps in close contact with cultivation in systems of mixed farming. Although the extension of white settlement to the point where stocks of pedigree European breeds have ousted native cattle from much of Southern Africa and the tropical highlands is not impossible, such development is very unlikely in the low-lying areas, or in the semi-arid

uplands which appear to be fit only for pastoralists. Hence the future prosperity of a considerable part of Africa lies in the improvement of native stock through the agencies of nutrition and breeding, together with a fight against disease, overgrazing, and erosion.

The improvement of stock, even by such simple means as castrating the unfit males and keeping the numbers down to limits compatible with the available pasturage, is rendered particularly difficult in Eastern and Central Africa by reason of the attitude of the pastoral native to his domestic animals. Not only is the man's status in society gauged by the size of his flocks and herds, but they are the object of deeply cherished religious beliefs, and the basis of the marriage custom, known as the payment of bride price, which is widespread all over pagan Africa. The essence of this custom is that the validity of the marriage contract depends on the transfer from the bridegroom's family to that of the bride of a certain number of cattle, goats, or sheep, which are returnable in whole or in part on the dissolution of the marriage or the death of the wife. This custom persists in the face of many social changes, and although there are tribes where cash has largely replaced cattle for this purpose, there are also many in which it is still held that only the transfer of cattle can validate a marriage. A striking instance of the attachment of natives to their stock is shown in the Bukoba district of Tanganyika where the people have become comparatively wealthy as a result of the extensive growing of coffee. As a consequence, they have begun to eat meat in considerable quantities, but although they possess large numbers of cattle of the long-horned type associated with Ankole, they will not sell these animals except at an absurdly high price, and indeed they import large quantities of cattle for slaughter every year from Mwanza, at the south of Lake Victoria.

Reference must be made again to the all-important question of water-supply for domestic purposes and stock. It is only where permanent water exists, in the form of perennial streams, water-holes, or wells, that stock can be kept all the year round. In the semi-arid regions which comprise so much of Africa's pastoral country, temporary supplies become available during the wet seasons and allow a diffusion of stock over wide areas taking advantage

of the pasture that springs up after rains, but during the long dry seasons men and stock collect near permanent water and thereby cause overgrazing, laying the soil bare to be washed away during the subsequent rains. Therefore, to counteract the ravages of overgrazing as well as to increase the carrying capacity of the land, the provision of additional wells and bore-holes and hydrological surveys is of great importance (*see* Chapter II).

STOCK SURVEYS

Improvement of stock either by breeding or improved feeding cannot be undertaken on true scientific principles without knowledge of the existing breeds, so theoretically the first step should be to make a survey of the native stock throughout the continent to ascertain the distribution of each breed, the nutritional requirements at different seasons, the rate of growth, the speed of attaining maturity, the breeding frequency, the milking capacity and quality on different diets, and above all, the resistance to disease. Though it is not possible in practice to await the full results of such studies, Sir Arnold Theiler, shortly before his death, emphasized the importance of surveying the characters of native stock before they become further modified under the influence of changed systems of husbandry or the introduction of breeds from other parts of the world. While much local knowledge has been gained by agricultural or veterinary officers little published material is yet available. Members of the Veterinary Division of the Union, especially Dr. H. H. Curson and Mr. J. H. R. Bisschop, have begun a thorough scientific study, and Dr. H. Epstein of Welverdiend, who is supported by the division and by the Research Grant Board of the Union, has extended his researches in native stock to the whole of Africa, and has in preparation a book on the origin of Africa's indigenous domestic animals. This will be of value to all those concerned with stock in the continent.

It appears that three foundation types of African cattle, the Hamitic Longhorn, the oldest African bovine, the Brachyceros or dwarf shorthorn type imported from Asia many years ago, and the Zebu or humped cattle, imported more recently from Asia, have given rise to the very numerous races which exist

to-day (Curson and Epstein 1934; Curson 1937; Stewart 1938). (1) The Hamitic Longhorn was probably developed from *Bos primigenius hahni*, the African urus, and is known to have been domesticated in Egypt in prehistoric times. The breed has disappeared from Egypt, but, in the opinion of Stewart (1938), is found almost pure in Liberia, Guinea, and parts of Morocco, being known in the former places as N'Dama cattle. The interesting Budama cattle of the islands of Lake Chad are larger editions of the N'Dama in conformation and points, although they differ in coloration, being black and white instead of dun; they would appear to be the nearest living cattle to the old African urus. Amongst other representatives of the Hamitic Longhorn are the Scottish West Highland cattle, which are also similar to the N'Dama in conformation and points, though the colder environment has produced a long shaggy coat. As the N'Dama are especially good for stock improvement, they have been extensively used by French and British authorities and the natives themselves, and have now spread over a large part of West Africa. (2) The Brachyceros or true Shorthorn is thought by some authorities to be descended from a small wild ancestor and by others to be a variation of the urus due to unfavourable environment, but whatever its origin, *Bos brachyceros* is a distinct type. The differences in osteology and conformation between the three great types have been discussed at length by Curson and Epstein (1934). The small Brachyceros cattle reached Egypt at the end of the Neolithic era and remained the principal breed until the arrival of the Zebu. According to Stewart the purest modern representatives of the original Shorthorn are the lagoon cattle of the coastal regions of West Africa, such as those in the Gold Coast in Appolonia, in the Brong country to the west of Yeji and along the Black Volta. They are very small, few being more than three feet high at the shoulders, and the predominant colour is rusty red-brown. The so-called West African shorthorns are a mixture of Hamitic Longhorn and Brachyceros, usually with Zebu blood also. (3) The term Zebu is broadly applied to humped cattle, but there are Zebu cattle without humps also. The Zebu is thought to be descended from *Bos namadicus*, the Asiatic Zebu, first domesticated in the steppe country of Central Asia, and its nearest modern representa-

tive is probably the Afrikander of South Africa. The Shorthorned Zebu, common to-day in many parts of Africa, originated from a fusion between the Zebu and Brachyceros cattle. The Sanga, described by Curson and Epstein, and found in Nigeria around Lake Chad, is an intermixture of the true Zebu and the indigenous Hamitic Longhorn. Crosses between these three foundation types probably gave rise to the majority of indigenous cattle south of the Sahara.

After this brief sketch mention must be made of a few results of stock surveys, which have been started in various parts of the continent, notably in the Union of South Africa, Uganda, Nigeria, and the Gold Coast. In the Union of South Africa it appears that since this part of the continent was known to Europeans there have been four distinct types of native cattle: (1) the Bechuana, inhabiting the arid central plateau (Curson 1934a). This is a large, strong, long-horned type, possessing the small hump which is characteristic of South African indigenous cattle. As native breeds go, the breed produces good quality milk and shows resistance to the common diseases. (2) The Hottentot or Namaqua, now the Afrikander, scattered throughout the Union and Southern Rhodesia (Curson 1934a). (3) The East Coast type, including the Makalanga which are the dwarfs of South African cattle (Bisschop and Curson 1933), and the Zulu (Curson 1934a). (4) The Ambo, which is able to survive on very poor pastures and shows pronounced resistance to disease (Groenewald and Curson 1933, Bisschop and Curson 1935). Varieties occur amongst these four types, either through interbreeding amongst the types or with European breeds, as in the case of the Damarara, or as a result of environment, as in the case of the Batawama (Curson 1934a).

In West Africa the small unhumped cattle, which cover the Gold Coast, Togoland, Dahomey, French Guinea, Ivory Coast (southern), Liberia and extend into Senegal, Mauretania, the Sudan, and Nigeria, are a mixture of the three foundation types. Stewart has named them West African Shorthorn, from their resemblance to miniature British Shorthorns; it should be emphasized, however, that the name is not intended to be used in any generic sense, as indicating a homogenous breed, but merely as a descriptive term. Genetically the West African Shorthorn is

extremely heterogeneous, a characteristic accentuated by the lack of any planned breeding (Stewart 1938). In the north, particularly the northern parts of the Northern Territories, the Zebu admixture is strong; there is increased size and weight, whilst the rise in the withers, dropped tail-head, more prominent dewlap, the voice, placing of the ears and shape of the quarters are all characteristic of the Zebu, and although the hump is absent, not all Zebus are humped. Along the coast and in remote bush areas where conditions are bad, the cattle are stunted and Shorthorn characteristics are more pronounced. The Hamitic Longhorn blood is usually most marked in the best and hardiest West African cattle, whether humped or unhumped. Three types of humped cattle are recognized in West Africa by Curson and Epstein: the Shorthorned Zebu is a fusion of Zebu and Brachyceros blood; the Sanga is a fusion of the Zebu and Hamitic Longhorn, and is found in Nigeria around Lake Chad, where in some regions it is the local indigenous ox; the crosses between humped and unhumped cattle in the Gold Coast are said by Stewart (1938) closely to resemble the Sanga; the Lyre-horned Zebu is a cross between Hamitic Longhorn and the Shorthorn Zebu, and is a very common type particularly in the Niger bend (Stewart 1938). The Fulani of Northern Nigeria, the Gold Coast, and neighbouring regions, who have bred and traded cattle from time immemorial and have perhaps as sound knowledge as any African tribe of the principles of breeding, have evolved at least five definite strains of humped cattle, one of which, used for milking, calves at two-yearly intervals and has a long lactation period. Neither Zebu nor Sanga has a high resistance to trypanosomiasis, and their distribution is limited to lightly infested regions only. The Shorthorn, in general, whilst its resistance to rinderpest is considerably less than that of the Zebu, has a higher resistance to trypanosomiasis, a character which is especially prominent in the dwarf races of the regions near the Gulf of Guinea. These little animals can survive in densely vegetated country infested with tsetse, where the larger animals from the north always die from trypanosomiasis in a few weeks (Faulkner and Mackie 1933, p. 157). A further factor in resistance to trypanosomiasis is that while many cattle have a high degree of resistance to local strains, they have little or none to

strains of the same parasite from a different locality. Only the N'Dama has proved able to withstand different strains, as well as possessing a high degree of resistance (Stewart 1938). The distribution of stock in all West Africa has been mapped by the French authorities (Grandidier 1933): the line of distinction between the Zebu in the north and the West African shorthorn (*petit bœuf sans bosse*) in the south cuts Nigeria at the latitude corresponding with the northern border of Dahomey and runs westward to the Senegal River. For some distance on either side of this line crosses between the two breeds predominate, and Mr. J. L. Stewart states (Curson 1934b) that these cross-bred cattle seem to inherit the worst points of each, perhaps owing to uncontrolled breeding. Curson (1934b) also gives brief references to the cattle of other territories in West and North Africa, including French West Africa, the Cameroons, and Liberia.

In Uganda the cattle types have been the subject of study: there are two widely divergent breeds, the humped Zebu with short horns, which predominates in the Eastern and Northern Provinces, and the long-horned, straight-backed breed of the Western Province, usually called Ankole. Cross-bred strains occur with the two parent types and occupy the greater part of Buganda Province. It is suggested (Thomas and Scott 1935, p. 195) that the Zebu was established before the longhorn, which apparently accompanied the ancestors of the Bahima on their arrival in Uganda perhaps four or five centuries ago. Data on the numbers and distribution of cattle in Uganda, collected in 1933–4, have been compiled in the form of a map published by the Veterinary Department (Uganda, Veterinary, 1934, *D.R.*) and similar figures have been collected during a cattle census in Tanganyika (Tanganyika, Veterinary, 1935, *D.R.*, p. 28).

Da Costa (1933) has described the native cattle in the Portuguese possessions. These include a small humpless race in Portuguese Guinea, claimed to be a representative of *Bos primigenius* and closely related to the cattle of Morocco and Algeria. It is noteworthy that da Costa holds a different view on the origin of the Afrikander from that of Curson and Epstein.

IMPROVEMENT OF STOCK

CATTLE

The improvement of cattle in Africa by breeding or other means has in the past been carried out partly in order to produce high-grade herds for ranches belonging to non-natives, mainly for beef, but in certain instances for dairy purposes or draught, and partly for the improvement of native-owned stock. These two objects need not be treated separately, since the scientific problems involved are essentially similar. Dr. F. Darling (1934), when at the Imperial Bureau of Animal Genetics, wrote a general account of animal breeding in the British Empire, which has served as a basis for the following account, but is supplemented by later information. The main consideration in all African stock breeding is that the 'degree of improvement must always be dictated by the plane of nutrition'; neglect of this has sometimes led to disappointment in attempts to grade up high-class imported stock.

In the *Union of South Africa* many of the most productive British breeds of cattle have been successfully acclimatized; in particular the Ayrshire and Friesian cattle are equal to the best in the world. The rapid development of the dairy industry in South Africa, indicated by the growing exports of cheese and butter, demonstrates the result of these introductions. The Afrikander breed, referred to above, is generally, but not universally, regarded as the most valuable heritage of the cattle industry, and the most useful beasts possessed by South African farmers have been produced by suitable crossing with introduced pure breeds. This is particularly so in relation to the beef industry, which most authorities consider must always be based on the Afrikander, since it is a superior animal to other native stock and appears to possess unimpaired those qualities of resistance to disease and ability to forage under stiff conditions, which are essential in a ranch animal in subtropical countries. The Afrikander is, however, slow in maturing and one problem has been to speed up its growth without impairing its adaptability. D. J. Schutte (1935) has reported on the beef-cattle bred in South Africa and the application of methods used in America to the Union. He does not favour straight grading with pure-bred bulls of British breeds, neither does he wholly sub-

scribe to the common practice in South Africa of crossing (plaiting) three breeds. He recommends the use of first-cross bulls from European bulls, of which the Sussex give the best results, and Afrikander cows, on the ground that more bulls can be put into service and can be kept under wider natural conditions than the pure-bred sires. The object of crossing is to improve the beef type, speed of maturity and other desirable characters by grading up the Afrikander. For this purpose Schutte advocates extensive supplementary feeding. In order to bring the improved type into harmony with the environment, it is important to recognize, however, 'that the South African environment has already developed the type of cattle most suited to it, and that it remains for a co-ordinated system of stratification to be developed, using the principles which Dr. Schutte has so ably explained' (Darling 1936). This aspect of the ecology of South African cattle farming has been well emphasized by A. M. Bosman (1932). The authorities mentioned here in general agree that the Afrikander has many qualities superior to those of other native breeds in South Africa, but this conclusion is not universally accepted, and some experts regard other native races as being still more valuable for certain purposes. The opinion is often expressed, moreover, that if more than 50 per cent of European blood is introduced into native stock in the Union and the Protectorates, retrogression instead of progress will result when these cattle are bred under natural conditions, on account of their inability to adapt themselves to difficult environmental conditions.

In *Southern Rhodesia* also it is widely held that the best type of beast is the grade animal. The three races of native cattle there are the Angoni, which is active, small, with a slight hump, the Mashuma with a straight back, and a huge humped type of Zebu. Each of these is regularly crossed with imported bulls, particularly Herefords and Aberdeen Angus; Devons and Shorthorns are also used for the purpose. The second cross, giving beasts with three-quarters of the beef strain and one-quarter native, is claimed to be the finest ranch animal, being almost indistinguishable from the pure-bred, but retaining the native capacity to thrive on natural grazing and to resist diseases. The seven-eighths pure-bred also does well, but beyond that, further grading is considered to be

rash, because the native adaptability is practically obliterated.

The rest of Africa south of the Sahara presents rather different problems in the improvement of cattle. Work in the British territories has been summarized by Darling (1934) and Professor R. C. Wood (1934), who reach the general conclusion that results up to date indicate that the introduction of *Bos taurus* from Europe, either to develop pure-bred herds or to grade up the native races of cattle, does not hold out as great hope in the colonial territories as it does in South Africa and Southern Rhodesia, though there are exceptions to this rule in some of the highland areas of Eastern Africa. That attention should be concentrated on the general improvement of the enormous herds of native-owned stock is generally accepted, but opinions differ as to whether this improvement will be best attained by selecting pure strains of individual breeds, by crossing breeds to produce offspring retaining the good qualities of each, or in certain cases by introducing foreign blood.

As a first step in improvement, the introduction of Zebu bulls, particularly the Afrikander of South Africa, has been advocated. Smith (1937) differs from this opinion and recommends the use of second-cross bulls from British bulls, in order to introduce some of the characteristics of the better breed, whilst preserving the hardiness of the local breed. In general, and contrary to widely held opinions he opposes the use of grade bulls for fear of possible atavistic reversions. Where very highly graded stock cannot be maintained under normal ranching conditions, he recommends the introduction of selected heifers from less advanced herds, rather than grade bulls. He also stresses the advantages of maintaining carefully selected herds of indigenous animals as part of a general breeding policy.

The possibility of improving native stock at once raises the problem of overgrazing. The difficulties created by the native attitudes to cattle, which have been mentioned in connection with soil erosion (Chapter V), present complex sociological problems. The most obvious and simple measure of improvement is the castration of inferior bulls, to ensure increased use of the better animals. This has been done in Uganda and elsewhere, but as soon as activity by the veterinary staff is slackened, the native reverts to his old ways of unselective breeding. Even in the castration of inferior

bulls it is easy to alienate native opinion, since the small bull is often active, and if only large lazy bulls are left in a herd, many cows may remain infertile for long periods, a result which, though desirable for reducing the head of stock, is unsatisfactory from the native's point of view. Moreover, before embarking on wide-scale castration of this kind, it is necessary to decide whether the stock is to be selected for beef, milk, or draught, since a breed potentially useful for one of these purposes may be spoiled by faulty selection. Different policies may be desirable in different parts of a single territory. In the tropical parts of Africa it appears desirable to breed local stocks selected for qualities appropriate to varying economic conditions, and for resistance to different diseases. In some parts of the continent where reduction in numbers is desired it might even pay to breed for sterility and to aim at having a certain proportion of sterile animals in every herd. In order to indicate the scope of the problem and the possible methods of attack, the work done in some of the territories may be described.

In *Northern Rhodesia* the cattle industry has been built up under protection from outside competition as an incidental result of disease restrictions. The recent development in copper mining has created a large market, but restrictions, especially in connection with foot-and-mouth disease, hamper the sale of stock. Considerable doubt is expressed, moreover, whether the industry could hold its own if free imports from Southern Rhodesia and elsewhere were permitted. Meanwhile, opportunity is being taken to improve stock by breeding, partly on the lines described above in connection with Southern Rhodesia. There is a government herd organized into subherds for experiments in grading with bulls of English breeds, the progeny being compared for rate of maturing, weight increase, milk yield, and resistance to diseases. Surplus stock either pure-bred or graded is sold to stock-owners.

In *Tanganyika* the chief problem is the redistribution of native herds to avoid overgrazing, which is discussed later. Although breeding naturally enters into this work, the nutritional aspects have been especially stressed by the Department of Veterinary Science and Animal Husbandry. Breeding experiments have been carried out by the department particularly with a view to producing a good type of dairy cow primarily for non-natives

(Tanganyika, Veterinary, 1934, *D.R.*, p. 73). Good types of native stock have been graded up by the use of sires of proved European breeds in experiments which were started at Dar-es-Salaam about 1923. Herds of half-grade Friesian and Ayrshire cows were eventually obtained, and the latter have been moved to Mpwapwa. The conclusion reached is that the half-grade animals give more milk than the native stock, and what is perhaps more important, they are more tractable and can be induced to yield milk without the presence of a calf at milking time. The three-quarter breds are again better and are bigger and finer beasts, but it is considered that the larger frame and earlier maturity involve such an increased demand for food that they may be less valuable to the territory. Native animals have also been crossed with the Krishna Valley Zebu, but when the offspring were found to be intractable creatures, although the parent stock were noticeably docile, the experiment was abandoned. The acclimatization of Indian buffaloes has been tried: they have proved good milkers, but require more food than native cattle and are susceptible to trypanosomiasis. Attempts, so far unsuccessful, are being made to see if the Indian buffalo can be crossed with the African one in the hope of producing a domestic animal suitable for tropical Africa. This is a particularly interesting experiment when it is considered how few animals have been domesticated by man and how perfectly the game animals of Africa are adapted to their environment. It is worth noting in this connection that in various parts of Africa the Eland, the largest of the antelopes, has been partly domesticated and kept with herds of cattle. The government stock farm of 5,000 acres at Njombe at an altitude of 5,000 to 6,000 feet was instituted in 1929 for the supply of improved stock to settlers and for general experiment. Here as elsewhere it has been found that the herbage is deficient in nutritive quality so that improved stock require extra feed in the dry season. Large-scale work with sheep has given no results and only small trials with cattle are being continued. (Tanganyika, Veterinary, 1933, 1934, 1935, *D.R.*)

In *Kenya* a general improvement of native stock should ensue from the compulsory culling of ill-conditioned animals in the native reserves, so strongly recommended in the report of Sir Daniel Hall's

(Kenya Commission 1929) and Sir Morris Carter (Kenya 1934). In the initial stages it appears that ill-feeling among the native stock owners is bound to be aroused, but it is held that the alternative of allowing potentially good stock land to change into desert through the ravages of soil erosion must be avoided at all costs. The concession for a meat factory at Athi River on the edge of the Masai Reserve obtained in 1936 by Messrs. Liebig, who are authorized to purchase 30,000 head of cattle per annum from the Masai, is an important step in this direction.

Many efforts have been made in Kenya by settlers to establish pure-bred herds of British breeds and to grade up native stock. Results have by no means always been a success, but many high-grade herds of dairy cattle are now established in the highlands. At the Government farm station at Naivasha Dr. Anderson is studying the correlation of nutritional conditions and reproductive activity. Attention is being directed on the one hand to a study of the influence of the plane of nutrition and of actual specific deficiencies upon the frequency of œstrum and the percentage of successful matings; and on the other hand the reproductive peculiarities of the Zebu are being investigated in order to find whether they are genetic characters of the species. Another centre of stock research is Ngong under Mr. J. Anderson, formerly of the Rowett Research Institute staff. A valuable experiment in the improvement of native breeds by selection for milk-producing qualities is in progress. Similar attempts at improvement are being made with herds of cattle of different native breeds at the veterinary training centres at Maseno, Baraton, Sangalo and Mariakani, where results of considerable value have already been obtained. It may be desirable in the near future to concentrate these breeding experiments at one centre, with a view to exercising a closer control of the work. Experiments relating to the improvement of native cattle are at present concerned entirely with the production of dairy cattle, but it is hoped to examine the potentialities of crossing native stock with a recognized beef-breed, such as the Hereford, Pollen-Angus, or Dexter-Kerry. For this purpose it is believed that the technique of artificial insemination, which has been studied on the Naivasha stock farm, may have important applications. Among the nutritional studies may be mentioned

a blood-mineral survey in various type districts of the colony. This was begun in 1936 and includes a complete pasture analysis, both botanical and chemical. The pasture work in Kenya carried out by the animal industry division has been mentioned in Chapter VI. In the East African highlands economic data show that the dairy industry must include crop production for animal feed in order to tide over dry seasons. Dairy work cannot be run as a ranching business, except perhaps by natives, on account of the poor quality of pasture.

In *Uganda* general observations on indigenous cattle at the experimental stock farms have confirmed the opinion that it is desirable to concentrate on the breeding of draught animals and on selection for beef production rather than on milk production. For example, at Serere it is hoped to establish a breeding herd with the single purpose of producing better draught animals for the Eastern Province, where the plough has largely superseded the hoe. It is also thought that breeding will have to be carried out for each different locality, on account of the prevalence of particular disease in different areas. Since Uganda offers some particularly fine native races, such as the famous Ankole longhorn, to serve as a background for selection, the introduction of European breeds is coming to be regarded as unnecessary and undesirable. The activity of the veterinary department in the organized castration of weakling bulls in the native herds has already been mentioned.

In *West Africa*, there have been some notable achievements in Nigeria and the Gold Coast. African conditions with regard to nutrition and disease must be taken into account in all improvement: in particular, the extent of trypanosomiasis renders any reduction in resistance a great disadvantage. Stewart (1938) estimates that all cattle in the Gold Coast are exposed to trypanosomiasis infection at some time or other; tsetse belts, such as exist in East Africa, are rare in West Africa, but during the rains and floods of August and September, the tsetse are driven from their permanent habitat into the surrounding country, with the result that infection of cattle is inevitable. This prevalence of infection makes the addition of blood from European breeds almost useless, and even the Zebu can only survive in the more lightly infested northern regions. Sir F. Stockdale (1936) has given a critical

account of present activities in the British West African colonies.

In *Nigeria* the cross between the West African shorthorn and the Zebu, practised by some native cattle-owners, produces an animal which closely resembles the Sanga and is intermediate between its parent stocks in size and resistance and probably in milk yield also. This breed could probably be improved, but it is an open question whether it would be possible to evolve a breed with sufficient resistance to trypanosomiasis to be valuable except in very restricted areas. Accordingly, improvement of each of the pure breeds appears the more promising line of work. On the stock farm of the agricultural department at Shika, near Zaria, in charge of Mr. Brown, experiments have been in progress for a number of years with three of the five most distinct types of native Zebu: namely the White Fulani, the Godali and the Shuwa. In addition a small herd of a fourth type, Adar, has been maintained at the agricultural station at Samaru nearby. The aim of these experiments is to produce races with heavy milking cows and good working bullocks, intended primarily to be used for mixed farming. The present policy in breeding is to keep the White Fulani and Godali pure, since on the whole they are the best dual purpose animals, the former being a little superior for work and the latter for milking (Nigeria, Agriculture, 1935, *D.R.*, p. 32). The Shuwas are considered to be too small for work, and so it has been decided to grade half the herd to White Fulani and the other half to Godali. The Adar herd similarly are to be graded to Godali. Nutritional problems likewise receive attention, and marked increase in growth, breeding frequency, and milk production results at once from improved food supply.

The dwarf races of West African Shorthorn, which show such high resistance to trypanosomiasis in the southern areas, have not yet been the subject of intensive study in Nigeria, though several experts, notably Stockdale (1936) have stressed their possibilities. A herd of the resistant small races of the Gold Coast was, however, introduced to Nigeria in 1934 and is proving its worth in spite of serious losses in transit. These animals, although small, can plough satisfactorily, so that it is not worth while to try to increase their size by grading up with the larger beasts of Nigeria. A proposal is under consideration to establish in Southern Nigeria a government

farm similar to that at Shika, but for work on shorthorn humpless cattle, chiefly to provide plough oxen (Nigeria, Agriculture, 1934 and 1936 *D.R.*, p. 20, and Anderson 1933).

Work on similar lines has been carried out in the *Gold Coast* at the Government livestock farm, opened at Pong-Tamale in 1931–2, under Mr. J. L. Stewart, the Principal Veterinary Officer, who has given a most interesting account of it (1938). Now that rinderpest has been practically eliminated, and contagious bovine pleuro-pneumonia is under control, trypanosomiasis is the greatest obstacle to stock improvement. Experiments with the West African Shorthorn have confirmed those from Nigeria, and show that these cattle possess resistance to local strains of trypanosomiasis, whilst the failure of attempts to grade up native cows with bulls of British breeds, has shown that imported cattle are not successful and that improvement must be confined to West African Shorthorn cattle, or to types of West African Zebu whose progeny can thrive under Gold Coast conditions. Work with the N'Dama has proved most successful; crossing with N'Dama has been found both to improve the inferior breed and also to increase its resistance to the ordinary bovine diseases of West Africa. The present grading policy is, therefore, to restore a high proportion of the old Hamitic Longhorn breed to Gold Coast cattle, by means of the N'Dama. The improved bulls produced at Pong-Tamale are issued to the native administration farms in the Northern Territories, from which bulls are distributed to small farms and village herds, the aim being to improve the native stock by selection within the breed, and by some crossing with graded sires of related African breeds. The main Government farm also crosses bulls direct (Gold Coast, Veterinary, 1931–2, *D.R.*). In the coastal area the organization is somewhat different; a Government farm is under construction and the farmers' associations will take the place of the native administrations in the Northern Provinces (Stewart 1938). Stockdale (1936, p. 77) questions the improvement which is likely to be effected by introductions from French Guinea, and concludes that the introduction of strains from outside will only add to the complications which already exist, and will produce an even more heterogeneous collection of animals in the Northern Territories of the Gold Coast. He recommends the selection of

indigenous cattle as likely to have better results in the long run.

In the *French and Belgian* territories cattle improvement is likewise an important part of the work of agricultural and veterinary departments. Cattle are raised on the experimental farms mentioned in Chapter XII and distributed to native farmers, and breeding and nutrition are the subject of scientific study. French authorities have concentrated on sheep rather than cattle (see later), but in French West Africa three French cattle breeds, the Charollaise, Normande, and Tarentaise, have been introduced with varying success.

In the *Belgian Congo* the only stock-raising areas of note are in the highlands near the eastern frontier, in the districts of Uélé, Ituri, Kivu, and Katanga. In Uélé the native breed is improved by crossing with bulls of Shorthorn blood, introduced by the Mission de Buta. Ituri produces many beef cattle, and both ranching and kraaling are practised. The most scientific methods of breeding seem to be practised at Nioka, where the aim is to produce beasts suitable for both milking and beef. Records are kept of milk yields quantitatively and qualitatively, of the weight of cows and calves, and of rate of growth and development, and artificial feed is used extensively to supplement the poor pasturage (Congo Belge 1934 onwards). In order to supply beef and milk for markets in other parts of the Congo, cattle have been introduced to certain areas in the Bas Congo and elsewhere, and meat is supplied to markets at Boma, Matadi, Thysville, and Leopoldville, though at a high price. The chief breed used is that from Angola, which has been imported for many years. It has been crossed with various improved types, including the Hereford, Devon and Ayrshire, to improve milk and beef, and also the Friesland, Afrikander, and Breton. As in other parts of equatorial Africa, these breeding experiments have not produced the results hoped for, since the qualities which have been gained have not compensated for the loss of the stamina possessed by the native cattle. This danger is fully recognized, and the selection of native stock is proceeding side by side with grading up. Most of this work is directed to the improvement of milking and beef, but draught animals are being developed at Kisantu and Kitobola. In addition to the Angolan race, cattle have been introduced from Dahomey and Conakry,

particularly to the densely vegetated province of Coquilhatville. The milking capacity of these cows is small, and they do not reach full maturity for four or five years, but it is hoped to bring about improvement by selection.

On the *Portuguese colonies*, the following information has been supplied by Dr. A. d'Eca, chief of the veterinary services, and Dr. A Monteiro da Costa (1933) has written an account of the animal industry. The improvement of native cattle, whether owned by natives or Europeans depends, both in Angola and Mozambique, on conditions of health and nutrition and on measures against overstocking and the kraaling system, but here, as elsewhere, the European owner has greater capital resources. On the native side it is held that improvements in methods of animal husbandry can only be introduced by drastic measures taken by the department of veterinary services in collaboration with the administrative authorities and missions. Improvements in breeding are sought in three ways: castration and the selection of cows is made obligatory wherever possible; native cows are crossed with bulls of improved stock provided by the administration at numerous stud farms, and sold at very low prices or even given to chiefs or stock-owners as rewards; and thirdly native breeds are selected for improvement without the introduction of foreign blood. Experiments are now being carried out on the choice of breeds to be improved by selection, and a comparative study of the results of crossing and selection is in progress, but results are not yet decisive. The breeds of cattle imported into Angola for use on the state farms have been the Dutch Friesian, and its Portuguese variant, Turina, for their milk, the Portuguese Mirendeza for labour, and the Hereford, etc. for beef. In Mozambique in addition to the Friesland, the state has imported Afrikander, Shorthorn, and Hereford. It has been necessary to check unlimited importation by European farmers, because some of the breeds introduced would be harmful if widely used for breeding purposes among the native herds. The European is generally a cattle-dealer rather than a breeder, but in both colonies several investigations are being carried out by European farmers. In Angola grants for cattle breeding are made on special terms with the idea of stimulating the European farmer in the field of animal husbandry.

SMALL STOCK, ETC.

Sheep, like cattle, exist throughout Africa in a diversity of local indigenous races. Since sheep and goats have the flocking instinct well developed compared with cattle, they are preferred by some African peoples in country where large carnivora are abundant. Little enough is known about indigenous sheep, but it is important that very many of them have hair rather than wool, and therefore most of the industry in either wool or mutton is dependent at present on introduced European breeds, some of which have been rendered more suitable to the African environment by an admixture of indigenous blood.

In South Africa merino farming is an old established occupation, which was stimulated by the collapse of the ostrich industry, though most of the old ostrich farms are now devoted to cattle. It appears that the merino was originally imported to Australia from South Africa, but at intervals Australian sheep have been brought to South Africa to introduce new blood. The sheep industry has grown to far larger proportions than were ever attained by the ostrich industry. In 1931 there were 44,000,000 woolled sheep in the Union; the number fell to 27,000,000 in 1934, chiefly as a result of the severe drought which prevailed at that time, but, by 1936, it had risen to 30,000,000. Some of the world's finest wool is now produced there. The department of agriculture assists the industry through the work of its sheep and wool officers, who are in great demand by farmers, and through the inspection services instituted at the ports. The recent disastrous slump in wool prices has stimulated interest in mutton production; unless, however, this is developed separately, cross-breeding will inevitably bring about deterioration in the quality of the wool (Lewis 1935). The possibility of the production of fat lambs in many parts of South Africa is necessarily limited by the water-supply. Experiments carried out by the sheep and wool department of the University of Pretoria have given support to the theory that the sulphur content of merino wool depends primarily on hereditary factors, but that a deficiency of cystine in the diet of sheep lowers the sulphur content of their wool (Bonsma and Joubert 1934). Experiments to determine whether the feeding of cystine to sheep produces an increase in weight and quantity of wool, are in pro-

gress at Onderstepoort (Du Toit, Malan, Groenewald and Botha 1935). The results of experiments to determine the effect of nutrition and season on the secretion of wool-fat and suint in merino sheep are given in a paper by F. N. Bonsma and J. S. Starke (1934). The results of crossing merino ewes with four English breeds, the Romney Marsh, Border Leicester, Ryeland, and Dorset Horn, with a view to obtaining half-bred ewes for fat lamb production are outlined by Bonsma (1936). Breeding experiments and work on the characteristics of wool fibres are also conducted at Stellenbosch, Grootfontein, Ermolo, Potchefstroom, and Onderstepoort. Karakal sheep have proved their value in dry country, particularly in South-West Africa, where they saved many farmers during the economic crisis, and in view of the similarity of climate and conditions in certain parts of Bechuanaland, an attempt is being made to establish this industry in that Protectorate.

In the Kenya highlands, there are now well over 200,000 woolled sheep, mostly merino, and 9,000 cwt. of wool were exported in 1929. Although pure breeds can thrive in some parts, it appears that a proportion of native blood leads to better breeding and greater profits. It is proposed to experiment on the production of fat lambs, using a Southdown ram on merino or Romney Marsh ewes. Here the main question will be that of suitability of different types of pasture and whether there is need to grow special feed in order to obtain lambs of the right weight and condition within five months of birth.

The natives of East Africa are considerable sheep owners: in particular, the Masai of Tanganyika herd immense flocks on the higher ground. Many of these sheep are haired, resembling the Karakal in type; others are of the Persian black-haired type, while many are nondescript. There can be no doubt of the value of this indigenous stock in the development of an economic industry in a country possessing so many areas suitable for small stock. A problem is, therefore, to produce low-grade woolled sheep suitable for native pastoral areas. Here the artificial insemination, mentioned above in the case of cattle, will be valuable, because the technique has proved particularly easy in the case of sheep. In Tanganyika, the veterinary department received a grant from the Colonial Development Fund to investigate the possibility of raising woolled

sheep at the Njombe farm. Sheep were imported from Kenya, England, and South Africa, but the experiment proved a failure, and research is apparently now at a standstill. Proposals made by Europeans to try both woolled and haired sheep in the Northern Provinces are receiving attention. In the southern highlands sheep farming is impossible owing to a combination of soil poverty and helminth parasitism. (Tanganyika, Veterinary, 1935 and 1936, *D.R.*)

In the French territories more attention has been given to sheep than to cattle or other stock. Australian and South African merinos, Karakal and several French breeds have been introduced. In the wool-producing districts half-bred merino rams are distributed free to native breeders from whose herds ewes have been selected for crossing, and several government and state-aided companies are carrying on trials on a large scale. For example, work at the government animal farm at El-Oualadji in the French Sudan is confined entirely to the grading up of native breeds of horses, cattle, and sheep. Merinos have been used here with great success. Again, the Diré Company has established a flock of merinos, now numbering some 2,000 to use the grasslands behind their irrigated concession area near Goundam. Merinos have been crossed with native sheep to produce half, three-quarters and seven-eighths merino. The half-breeds have proved to be most resistant to disease.

In the pastoral areas of the Belgian Congo, to the north-east and south-east of the country, sheep are scattered everywhere, and certain native races have already attained considerable importance as a result of selection or crossing with imported breeds. In parts of Uélé the Sudan type of hornless haired sheep with fat tails have been developed by certain missions, but the chief efforts in improvement are at the Nioka Government farm in Ituri, where large flocks of merinos and Romney Marsh are naturalized. Native mutton is mediocre in quality, but that produced by cross-breeding with sheep from Nioka is much better. The mortality among sheep at Nioka is very high, and is chiefly due to helminthiasis. The changeable weather also causes the death of many lambs. In the western parts of the Belgian Congo, where native sheep are relatively few, and are scattered among the cattle in small

flocks, no special efforts have yet been made to improve them.

In the Portuguese territories, according to Da Costa (1933), native sheep are of two kinds, each with a distinct origin. The Mondombes variety, which is said to be akin to an Eastern breed, *Ovis aries asiatica*, occurs on the coast of Angola, to the south of Benguela. They have short hair, and the rams, owing to a division at the base of each horn, appear to have four instead of two horns. The majority of native sheep belong to the second group and are representatives of *Ovis aries sudanica*; they are generally without horns and have long hair behind.

In Angola attention is directed to wool and mutton. For wool Wanganellas and Portuguese merinos were first imported, but good results have been attained only with the latter, which have been improved in the colony with the Rambouillet and the early merino of French origin. Crossing with native stock has been successful in the highland districts. For meat production, improvements have been made with the Persian black-headed sheep of South African origin.

In most native areas of Africa goats are more numerous than any other domestic animal. By European farmers they are generally regarded as unprofitable, but to the native they are undoubtedly valuable as a source of meat and some races are used for milking. They are also essential for the payment of bride-price, particularly among the Kikuyu. In many parts of the continent goat skins are of high value, and are exported in considerable quantities, (*see* page 454). In many tsetse areas goats survive in small numbers where cattle fail to do so. It appears that some local races have developed a resistance almost amounting to immunity, but more frequently the occurrence of small flocks of goats in country lightly infected by fly is explained by the fact that their small size and their habits render them less liable than cattle to attack by flies. Also, they breed faster, so that depletion by disease is made good more quickly. It appears that goats in general are somewhat less susceptible to infection from *Trypanosoma congolense* and *T. vivax* than cattle, but more susceptible to *T. brucei*. The capacity of some goats to resist or avoid trypanosomiasis, their alleged immunity to that growing scourge in Africa—tuberculosis, and their astonishing ability to obtain food in difficult conditions, perhaps renders

them worthy of more serious consideration than they have received. In some territories importations of high-class goats, such as Alpine and Angora, have led to the improvement of local strains by grading.

Pig breeding, in common with other branches of the dairy industry, has received considerable stimulus in recent years. For a dairy industry that depends on butter and cheese to be fully remunerative at reasonable price-levels, it is desirable to establish a pig industry as an adjunct (Stockdale 1937, p. 84). In South Africa most of the well-recognized British breeds have been introduced with success; and the same is true for Southern Rhodesia, where the dairy and pig industries have recently been the subject of a full economic inquiry (Southern Rhodesia 1936). In the colonies, pig breeding, following the introduction of pedigree stock from Europe, has made considerable strides, and in many cases it has been found that pigs are affected less than introduced cattle by local diseases such as trypanosomiasis. Breeding has received a good deal of attention in the Iringa district of Tanganyika during 1935 after the establishment of the Mtitu bacon factory at Dabaga (Tanganyika, Veterinary, 1935, *D.R.*, p. 31).

The pig industry promises well in the southern territories of West Africa. In the Gold Coast crosses between local 'razor-backed' pigs and introduced Large Whites and Middle Whites produce grade pigs, which are issued or sold to breeders in the Colony and Ashanti. An interesting result of breeding is the production of a new type, the Pong-Tamale White, which is characterized by fatty degeneration: 'This type has gone on producing fatter and fatter progeny until the logical end—conclusion of lethality from overweight and fatty degeneration—has been reached and the type *per se* cannot be continued. This has been an interesting experiment from a genetical point of view and has been useful in quick-grading of the local razor-backed pig.' (Gold Coast, Veterinary, 1935–6, *D.R.*, p. 27.) In the French colonies, the chief pig breeds introduced for grading local races are Yorkshire and Berkshire, and in the Belgian Congo, Large Black and Yorkshire. In the latter territory pig breeding is carried on successfully in Uélé and elsewhere, and it is found that the pigs thrive if allowed to run wild and given a little extra food once a

day. At Stanleyville the local African pig has been crossed with the Large Black. The offspring produced are at first highly successful, but seem to degenerate as time goes on.

The distribution of horses is limited by the presence of tsetse fly, but in some regions horses have marked importance, as in the Emirates of Northern Nigeria, where saddle horses are extensively used. South Africa, the Kenya highlands and the Anglo-Egyptian Sudan are perhaps the chief centres of modern horse-breeding, and in each of these Arab and thoroughbred stallions have been introduced and distributed for service. In the territories bordering the desert regions, especially the Sahara, camel-breeding is an age-old industry. In the Anglo-Egyptian Sudan, the Government has given much attention to the improvement of transport camels, and interest in the Government studs, especially in the Red Sea Province, has been aroused so much among the natives that they are gradually abandoning the promiscuous breeding methods of the past.

There is a great field for improvement in the poultry of Africa. Work has hardly begun, except in the Union of South Africa, Southern Rhodesia and the settled parts of the tropics, where numerous introductions of pure breeds have been made.

Experiments in the domestication of the African elephant have been carried out in the Belgian Congo since 1899, but nowhere else in the continent. The results are given by Huffman (1931). A station was opened at Api in 1910 with thirty-five elephants, and another station at Gangala na Bodio was added later. Young elephants, twelve to fifteen years old, are captured for training, and are used for heavy work on agricultural stations, military camps, public works, etc., and the work of each is said to equal that of fourteen or sixteen oxen. There are forty-five at Gangala na Bodio, and an equal number at work elsewhere (Congo Belge 1934 onwards). On the whole the experiment may be regarded as a success, but the fact that African elephants are not now more widely used, suggests that their training is found to be too costly by comparison with that of other draught animals.

OVERSTOCKING

The following discussion applies to those areas where stock have increased in numbers either generally or locally to a point where the natural food supply is insufficient. It is intended to be considered in conjunction with the sections of Chapter V on soil erosion, Chapter VI on pasture research, and Chapter XIII on shifting cultivation.

There has been a certain confusion over the meaning of the term 'overstocking', but the definition given by Hornby (1936) makes it clear: 'Overstocking is defined as the maintenance of animals on a piece of land to the detriment of its carrying capacity'; it is not synonymous with soil erosion, which, as pointed out in Chapter V, may result from several causes, of which overstocking is one.

In many parts of the continent especially in East and South Africa, the effects of overgrazing on the vegetation and soils of the country are more serious than are those of shifting cultivation. It is generally assumed that the evil is the result of great increases in stock in recent years, and that the causes have been the cessation of inter-tribal warfare and the persistence of the lobola or bride-price custom.

It is important to recognize that the areas where overstocking is noticeable are not as a rule very large in extent; it is essentially the result of local congestion. An important contributory factor to this local congestion is water-supply. All cattle have to remain within reach of permanent water during the dry seasons, when the pasture is least capable of withstanding continual grazing and trampling. Some experts, among them Major McCall (Tanganyika, Veterinary, 1929, *D.R.*), lately Director of the Department of Veterinary Science and Animal Husbandry in Tanganyika, went so far as to suggest that the problems of that territory should be ascribed entirely to uneconomic distribution, local congestion and bad husbandry rather than to overstocking in an absolute sense. Captain Hornby, the present Director of the department, has surveyed the general situation in Tanganyika in several publications (Hornby 1934 and 1936). In his view about 40,000 square miles of the territory are stocked to saturation, and of these

25,000 are overstocked, including what was formerly some of the best land in the Lake, Central, Northern, and Western Provinces. He calculates that this land is still capable of carrying upwards of 2,000,000 cattle together with nearly the same number of sheep and goats, but at present is being asked to sustain half as many more.

Whether overstocking is relative or absolute, it is certain that grazing in some areas has produced erosion so extensive that the time required for recuperation of the soil and pasture has been lengthened almost to infinity. Several districts in Kenya and Tanganyika have been complete devastated. The Kenya Land Commission's Report (Kenya 1934, Part 2, paragraphs 955 and 956) instances cases where there is but one head of cattle to twelve acres, and yet practically no grass is to be seen. Evidence before that commission showed that within the memory of European settlers in the country the areas which now carry scarcely any stock, were covered with grass vegetation. By contrast with this state of affairs, Uganda is not, generally speaking, overstocked. In certain areas, however, there are now too many cattle and the surveys in progress are designed to elucidate the facts in order that measures may be taken in good time. Cattle population returns are given in the agricultural department reports for Bugwere and Teso, and show the rate of increase in these densely populated districts. It is clear that accurate data on this point are quite essential for progress in native husbandry.

In the great savannah and grassland belt which stretches without interruption from the Anglo-Egyptian Sudan along the southern border of the Sahara to the coast of Senegal, the results of overgrazing, though recognized locally, do not seem to be nearly so serious as in East and South Africa. Even in the densely populated Emirates of Northern Nigeria there appears to be little danger of an increase of stock to saturation point. Perhaps this can be explained by the longer time which the cattle-owning tribes have had for the development of husbandry in an environment which has not been markedly disturbed, as have Eastern and Southern Africa, by the coming of the white man and the sudden cessation of inter-tribal wars and cattle thieving.

Measures to prevent the consequences of overgrazing have been

dealt with more fully in the report of the South African Drought Commission (1923) than in any other document. Its conclusions, however, are not always directly applicable to countries outside South Africa. In that country erosion has been accelerated by the substitution of stock-raising on farms for the old nomadic method of herding. The farm is soon intensively overgrazed and eroded, and the large herd proceeds to attack another small area. A principal recommendation of the Drought Commission is that the kraaling of stock should be replaced by paddocking for the following reasons: kraaling involves much driving, increased food requirements and trampling; grassland management depends to a large extent on periods of rest and recuperation for the pasture, and this is impossible until rotational grazing can be controlled by paddocking; the much debated use of fire as a stimulant to young nutritious grass can be controlled adequately only if the land is divided up into paddocks by fencing. On the whole opinion is tending to regard firing as generally deleterious since it promotes erosion as well as the growth of the young grass. The Drought Commission's report stresses that the wide areas of veld country, which can only be kept fit for grazing by annual firing, would be much better under forest, but there is no proof yet that they would support forest if planted. These questions depend to a large extent on the plant ecology and the improvement of pastures, subjects which have been discussed in Chapter VI.

More recent researches in South Africa tend to show that the problem of overgrazing is even more complex than was demonstrated by the Drought Commission, and in particular that the substitution of paddocking for kraaling, though highly desirable, is by no means a cure-all, and in many of the areas now seriously affected is likely to be uneconomic for a long while to come. This last contention applies still more forcibly to the pastoral areas in the native territories. Perhaps a system of paddocking and the cultivation of pastures will be the eventual condition of animal husbandry in native as in European areas, but obviously the cost of fencing will remain far too high for the average peasant for many years to come. An alternative method of enclosing land, possible in some areas of suitable climate, is to plant thorn fences and trees. It has been pointed out that this could be done in every

part of Uganda. It would involve changes in native systems of land tenure of a type which is thought by many to be the first logical stage in improving the lot of the native and in preserving his land for future generations. Meanwhile, other more easily applicable measures are under trial.

In the native territories of South Africa the position is bad. Mr. R. W. Thornton, who was transferred from the Department of Agriculture to the Native Administration in 1929 to make a survey of the situation, reported in 1933 (unpublished) that all the native areas were carrying four times as many stock per 1,000 morgen as the European areas, with the result that pastures were seriously denuded and erosion had set in. For example, in Natal, except in parts of Zululand, it is said that three-quarters of the total area is affected by soil erosion; the present reduction of productivity is estimated at 10 per cent and, if erosion continues unchecked, this percentage is likely to rise to forty in twenty years time. As Director of Native Agriculture in the Union Mr. Thornton has devised a method which has led to reductions in the number of stock without undue trouble. During some four years he has succeeded, through the medium of public auction sales, in securing the disposal of thousands of native-owned cattle for slaughter and other purposes. Such stock sales are now established in Bechuanaland, Transvaal, Natal, and Zululand, that at Nongoma in Zululand being the most successful; at one sale there £3,594 was realized. The success of such sales, however, necessarily depends on the general economic condition of the peoples concerned and the relative value which they attach to cash and stock. This has been the initial stage in a programme of which the aims are to reduce numbers and especially to eliminate thousands of undesirable bulls (some 47,000 have already been eliminated); to improve cattle by selection and the use of improved bulls, under what has become known as the 'Bull Camp Scheme'; and to introduce a six-years' rotational grazing system which, if correctly carried out, should preserve the pasture for all time. A compulsory fencing proclamation was made in 1931, and this has been applied to Msinga, where work has been financed from the Zulu Native Trust Fund.

In East Africa several recent reports, which suggest measures

for alleviating overgrazing, aim principally at the establishment of meat factories to dispose of all poorly conditioned animals. For East Africa, the reports of the Agricultural Commission under Sir Daniel Hall (Kenya 1929), and the Land Commission under Sir Morris Carter (Kenya 1934) both lay special emphasis on this matter, and as a means of reducing stock, taxation is suggested, though neither report makes this a definite recommendation. To meet the indifference of the native to money and his traditional attachment to livestock, Sir Daniel Hall (1936) put forward the suggestion in his Heath Clark lectures, that the purchases of cattle for meat factories might be met by the issue of a large coin or token stamped with the image of a bull, of the nominal value of £2, and of a smaller 10s. token for sheep. As he points out, the suggestion may sound fantastic but the situation it is designed to meet is also fantastic.

In Tanganyika the redistribution of population from the foci to the peripheries of the grazing areas has been considered by the animal husbandry, tsetse research and other departments. Until new permanent sources of water-supply for man and beast are made available, it will be impossible to make such redistribution permanent, but meanwhile it appears that rotational grazing could be established in many areas by inducing the pastoralists to leave their foci for six months each year, during the wet seasons. The six months' complete rest which the home pastures would thereby receive, is considered sufficient to enable them to recuperate enough to withstand grazing during the dry season. Since the average annual rainfall in the greater part of the territory is twenty inches, it should be possible, by means of shallow dams, to conserve sufficient water to maintain stock during the rainy season on what is now uninhabitable savannah or grassland. Experiments carried out with the co-operation of the department of tsetse research during 1933–4 showed that these methods were successful on a small scale (Staples 1934, *D.R.*), but difficulties such as the clearing of fly from infested areas, and the disinclination of owners to send cattle away when grazing is available in the neighbourhood, have yet to be overcome. It has been suggested that a system of communal ownership controlled by tribal grazing rules might solve the last-mentioned problem. A large-scale practical attempt

is now in progress in the Lake Province of Tanganyika to rest the home pastures for some months each year in the way outlined above (Hornby 1936, p. 51 and Tanganyika, Veterinary, 1936, *D.R.*, pp. 31–2). In certain areas it is probable that rotational grazing of this type will have to be combined with the culling of weakened stock, perhaps even against the wishes of the cattle-owners. Hornby points out, however, that the culling of weakened stock would have little effect on overstocking because so few animals can truly be regarded as less strong than the others. The struggle for existence in the overgrazed areas is so keen that the standard of health and vitality is remarkably high, although all the animals are stunted.

This question is closely bound up with efforts to introduce mixed farming, discussed in Chapter XIII. Mixed farming would create a definite use for stock manure, so much of which is now wasted, while the products of tillage could be used to some extent for stock feed during the dry seasons. As has been pointed out, the drastic reduction in stock which mixed farming would involve is a serious obstacle to its widespread adoption.

Recent experience in many parts of the continent has shown the value of contour-ridge-terracing as a deterrent to erosion and as the best means of reclaiming eroded land. This is applicable to pasture as well as to cultivated land. The object is twofold, to prevent wash, and to secure an equal distribution of the water over the land, thereby assuring a maximum absorption in areas of comparatively low rainfall. The system is easiest to introduce in areas of white settlement. In South Africa, for example, the value of the contour furrow is regarded as the most effective of recent reclamation measures. But it has great possibilities also in thickly populated native areas; indeed, many native cultivators already practise it.

Overgrazing by native small stock is becoming almost as serious as that by cattle. Sheep tend to crop pasture closer than cattle, and goats, though subsisting chiefly on the foliage of shrubs and trees, will eat almost anything, including grass. There seems little doubt that sheep are more apt than cattle to pull grass up by the roots and thereby reduce the recuperative powers of pasture. The same accusation is often made against goats, although on the

authority of Hornby (1936) goats leave the grass alone so long as bushes and herbs are available and do little to initiate erosion. Precise information about the effect of native small stock is lacking, but almost invariably they are described as uneconomic and unprofitable. Leakey (1934) has discussed the position of small stock of the Kikuyu reserves in an illuminating paper. He points out that in parts of the Kikuyu reserve an average family of six has only 16·2 acres of land on which to produce its own food, timber and firewood, as well as a surplus for sale, and to provide grazing for herds of goats, sheep, and sometimes cattle. The great increase in bride-price (a man is now required to hand over sixty to one hundred sheep and goats on marriage) has, in Leakey's opinion, added very largely to the overstocking problem. He considers that the solution to the trouble in Kikuyu can only be brought about by (1) reduction in bride-price instigated through the native councils, (2) improved agricultural methods to obtain greater return by intensive farming, and (3) making the uneconomic small stock economic by a slow substitution of hardy wool-bearing sheep and milking goats. It is hardly necessary to point out that the last suggestion does not take into full consideration the fact that milking goats require a much higher plane of nourishment than the usual native goats, as has been shown by experiments at Mpwapwa in Tanganyika. On the whole it appears necessary to solve the local problems of overgrazing before, rather than after, the introduction of milking goats or even wool-bearing sheep.

ANIMAL DISEASE

GENERAL

Before outlining some of the great work which has been accomplished in Africa in the scientific study of animal diseases, it is necessary to reach a definite conclusion on the relationship between the control of disease and that of overstocking. There is no doubt that the control of many of Africa's worst diseases has contributed to the increase of stock to numbers which were formerly impossible, and in certain cases may even have contributed to the trouble of overstocking. It has even been suggested that before campaigns

against diseases such as rinderpest and east coast fever are undertaken, an outlet for surplus stock must be ensured in every area, and that veterinary science in Africa has been attempting to cut its own throat, so to speak, by controlling disease at too early a stage. That such a *non possumus* attitude is scientifically untenable seems proved by the following considerations. It is probably true that in a state of nature, animal disease to some extent counteracts overgrazing, but it is only one among many factors, such as starvation and attacks by carnivorous animals, which contribute to keep down the increase of stock. Moreover, as a means of control, disease is clumsy and indiscriminate. It does not necessarily kill, but often only weakens, and efficiency is impossible in a diseased community where overheads remain the same, while production is reduced. The native's preference of quantity to quality is probably a direct consequence of the uncertainty which has in the past been associated with animal life in Africa, and cannot be altered by teaching the native to place quality before quantity, until he is given a sense of security by protection from the risk of decimation by disease.

It is possible to go still further than this, and claim that disease is not the natural cure for overgrazing, but is actually an important, perhaps the most important, cause of the trouble. This is the view held by Captain Hornby (1936), who points out that the overstocking question is acute in Tanganyika because four-fifths of the stock population are concentrated on one-ninth of the land, almost entirely owing to the ravages of disease. '. . . The native husbandman is only capable of maintaining large flocks and herds on land, the vegetation of which is indicative of arid or sub-arid conditions, since land with persistent vegetation favours ticks, flies, and worms, against the ravages of which the unaided native is helpless. Therefore, because overstocking inevitably tends to produce aridity and to reduce the incidence of parasitic disease, native stock-owners favour it, preferring seasonal losses from starvation, which they can understand, to continual and greater losses from disease, the nature of which is beyond their comprehension' (Hornby 1936, p. 355). The deduction from this argument is that the redistribution of population and stock may be accomplished and hence the problem of overstocking solved

without great difficulty, after, but not until, the major animal diseases are under control.

The following paragraphs in which the major diseases are discussed, are intended to be considered in conjunction with other parts of this volume in which special studies bearing on the problems are outlined, namely Chapter VI, section on pasture research, Chapter VIII, sections on animal ecology and conservation of wild animals, and Chapter X, sections on tsetse flies, insects and ticks in relation to diseases of stock.

Only a small part of the vast literature on animal diseases can be mentioned here as illustrative of the kind of work in progress. The most complete and up-to-date work for general reference appears to be the three volumes by G. Curasson (1936) in which full bibliographies are given for all known 'exotic' animal diseases.

In general it may be claimed that many of the principal diseases are now controllable: horsesickness, blue-tongue, redwater, gallsickness, anthrax, black quarter, and various other diseases can be controlled by immunization. Rinderpest is still a major problem in some parts of Africa, but with the aid of vaccination it too can be kept in check; the Union of South Africa, and the Rhodesias, as well as other territories, are entirely free from this dreaded disease. No satisfactory method of immunization has been devised against east coast fever, but the disease is controlled in many parts of Africa by means of dipping to eradicate the tick vectors, and quarantine. Dipping has brought untold benefits to stock farmers in the Union of South Africa and other territories, in many parts of which animal farming would be impossible without it. Even in many native areas dipping is now employed on a large scale. With the elimination of major diseases, numerous minor diseases, some peculiar to the tropics, East Africa in particular, and some common in Europe and other countries, assume a relatively more important position. The direction of research is consequently changed, and investigations are now being made into sterility, abortion, catarrh of cattle, respiratory diseases of sheep, deficiency diseases, etc.

SOUTHERN AFRICA

In the understanding and control of many diseases the work of

the Onderstepoort laboratory is outstanding, and the reports of the Director of Veterinary Research, of which eighteen large volumes appeared between the years 1908 and 1932, contain the results of researches carried out at the laboratory. Since 1932 these annual reports have been replaced by the *Onderstepoort Journal of Veterinary Science and Animal Industry*, which is published quarterly and comprises two volumes per year. The basis of tropical veterinary medicine was laid by Sir Arnold Theiler and his co-workers at Onderstepoort, and so important have the results been to the whole continent in leading to direct measures of control and in opening up fields for further research, that a few of them may be outlined.

Many African diseases are transmitted by ticks, and in the case of several diseases Theiler was the first to analyse the process. Mention should also be made of the brilliant research work of C. P. Lounsbury in the Cape, who determined accurately the transmission of biliary fever of dogs by ticks (*Haemaphysalis leachi*) and of heartwater by *Amblyomma hebraeum.*

The most important of the tick-borne diseases is east coast fever or *Piroplasmosis* of cattle. At the beginning of this century practically nothing was known about the blood parasites of cattle, and only Texas fever had been described in America and a similar disease found in Europe and other countries. Then east coast fever was recognized as a separate disease, and the parasite, *Theileria parva*, was discovered by Theiler in 1904. In 1906 Theiler discovered another parasite, *Theileria mutans*, very similar to *T. parva* in the blood of cattle. This was one of the parasites which was held responsible for the so-called 'gallsickness' of cattle in South Africa, but in 1910 Theiler found that another parasite, *Anaplasma marginale*, was the real cause of this disease. A variety of this parasite, *A. centrale*, was found to produce a mild form of the disease and to be an excellent immunizing agent.

At Onderstepoort also it was discovered by Cowdry that heartwater was caused by a *Rickettsia.* Blue-tongue in sheep was found by Theiler to be due to a filterable virus, which was subsequently attenuated and a very reliable vaccine placed on the market. Horsesickness was similarly elucidated and methods of prevention have recently been adopted by preparing a neurotropic mouse-

brain vaccine. A further virus disease of horses, ephemeral fever, was studied and its nature determined.

Pioneer work has been done at Onderstepoort on worm infections, particularly in sheep, by Theiler, Veglia, Mönnig, le Roux, Ortlepp and others. The life histories of several important parasitic worms were worked out and methods of treatment devised. The treatment of wireworm infection (*Haemonchus contortus*) by means of a mixture of copper sulphate and sodium arsenite was so effective and became so popular, that the issue of this powder assumed collossal dimensions; 25,000,000 doses and more have been issued in one season. Quite recently a further notable success was achieved when the dreaded nodular worm infection of sheep *Oesophagostomum columbianum*, was successfully treated by Mönnig with a mixture of copper tartrate and copper arsenate; millions of doses of this powder are now being issued annually. The role of *Schistosoma* in sheep and other domestic animals was also elucidated.

Nutritional problems have figured largely in the research programme of Onderstepoort (Theiler, Green, Malan, and others). The importance of phosphorus deficiency was first determined in South Africa, and far-reaching results were obtained. Further study of the minerals in nutrition led to the solution of the lamsiekte problem which for so many years puzzled scientists in the Union (*see* Chapter VI). Botulism in horses, ostriches, and other animals was also studied and brought under control. In connection with deficiency diseases, many detailed studies on pathology, especially of bones, have been made by Theiler.

Poisonous plants have received much attention at Onderstepoort. The etiology of diseases like gousiekte in sheep (caused by *Vangueria pygmaea*), vermeersiekte (vomiting disease, caused by *Geigeria* spp.), jaagsiekte in horses (caused by *Crotolaria* spp.), etc., have been worked out, and the peculiar relation between hairlessness in goat kids and poisonous plants (*Chrysocoma tenuifolia*) eaten by the mother ewes was shown by Steyn.

Among successes in the eradication of diseases in South Africa may be mentioned the following. Pleuro-pneumonia has been stamped out completely. Foot-and-mouth disease, which quite recently threatened the territory, was kept out by a vigorous cam-

paign. Lymphangitis and glanders have practically disappeared from South Africa, and scab in sheep has been reduced almost to vanishing point. The veterinary research which has come from South Africa, is indeed extensive, but in turning the pages of the Onderstepoort reports and journal it is difficult to avoid the conclusion that the results would now be more widely known and, therefore, of greater use to the world at large, if rather less unfinished work had been committed to print.

EASTERN AFRICA

In Eastern Africa, many of the results from Onderstepoort have been capable of direct application, but local investigations have also been necessary, and every territory has developed its own laboratories for the preparation of serum and vaccine and for veterinary research, as outlined in Chapter XI. In 1934 an important conference on the co-ordination of veterinary research in all East Africa was held at Kabete (Conference, East Africa, 1934b), and an attempt was made to allot to each laboratory those branches of research which it was best fitted to carry out. At the same time the possibility of centralizing research for the East African group of British territories at a headquarters laboratory, probably Kabete, was discussed at some length.

It is only natural that the cure and prevention of animal disease on European-owned estates was the first to receive serious attention, but latterly the results have been applied intensively in many purely native areas. The four most important diseases of cattle in East Africa are rinderpest, east coast fever, pleuro-pneumonia, and trypanosomiasis, but the last-mentioned has never had the importance in Kenya that it has in Tanganyika and Uganda.

In research, the laboratory of the Kenya division of animal industry at Kabete has perhaps been foremost, so some of its work may be considered by way of illustration. On *rinderpest* (Walker 1929a, Daubney 1929, Kenya 1935, *D.R.*, Pt. 2, p. 138), steady progress has been made, till it is now as capable of control as anthrax and black quarter. The double-inoculation or serum-simultaneous method of immunization was developed especially by Mr. J. Walker at Kabete, and was for many years the main method of control. It has been claimed by some that a tick-

borne disease, *redwater*, was spread in Kenya through the agency of the double-inoculation for rinderpest. It is true that certain catastrophes occurred through animals immune to red-water being used in the preparation of the serum which was subsequently inoculated into animals susceptible to redwater, but it is definitely concluded now that the disease can have spread no further than the actual animals inoculated, because redwater ticks, wherever they occur, are always infected with the disease. After extensive investigations on the virus of rinderpest, a new method of vaccination with mactivated spleen tissue was developed in Kenya and elsewhere between 1926 and 1928. The vaccine is found in East Africa to give two to two and a half years' immunity, and can be used without the elaborate organization of staff necessary for the double-inoculation method. The vaccine is expensive to manufacture, but in the light of recent discoveries on filterable viruses, it is probable that rinderpest vaccine can be considerably improved, and one of the projects upon which work is now being concentrated at Kabete is to discover a method of producing the vaccine at not more than 25 cents per dose. Policy in the control of rinderpest in East and West Africa is framed to suit the individual needs of the territories concerned, and since there is no uniformity of conditions there is no need for uniformity in the method of control. Collaboration exists between veterinary authorities on this subject, but it seems unfortunate that so much laboratory work has to be devoted to the preparation of sera and vaccines for rinderpest and other diseases. If a means could be devised whereby these necessary materials could be prepared at some central headquarters, the laboratories and staff in each territory would be free to undertake further research.

The work on *east coast fever* at Onderstepoort mentioned above, has been extended in Kenya, where it has been confirmed that a satisfactory method of immunization can probably never be devised since naturally acquired immunity is built up by successive attacks in calfhood (Walker and Whitworth 1929). Experiments have led, however, to an understanding of the value of dipping at short intervals for the prevention of this and other tick-borne diseases. This work has been combined with an intensive survey of the distribution of ticks, as mentioned in Chapter X, and systematic

tests on the common species to ascertain their ability to transmit the disease. Early work in South Africa, especially that by Walkins and Pitchford in 1906 suggested that regularly dipped animals are protected, either against tick bite or against infection with the protozoan parasites, by a concentration of arsenic in the superficial layers of the skin. Observations made at Kabete have shown that this is not the case, but that the effect of dipping is the obvious one: ticks are collected by cattle and carried to the dipping tank for immersion; a proportion of the ticks survive to finish their feed and even to deposit eggs, but the number and viability of the eggs laid are considerably reduced (Cowdry and Ham 1932, Cowdry and Danks 1933, Kenya 1930, *D.R.*). In this way the numbers of ticks are reduced to a point at which it becomes extremely unlikely that an infected animal will transfer its infection to a sufficient number of clean ticks for the disease to be carried on. It is evident that a certain density of stock is necessary for the rapid cleansing of pastures, and that fencing is complementary to the dipping. It has been demonstrated at Kabete and on a number of farms that susceptible herds of cattle can be maintained in health in the centre of highly enzootic east coast fever areas, but in the preliminary cleansing of pastures it is highly advantageous to stock with immune animals. It is clear that research on east coast fever and kindred diseases has now reached the stage when any area of land can be rendered free of ticks, and the veterinary authorities in Kenya and elsewhere are constantly urging intensive campaigns for this purpose.

A diagnostic test for *pleuro-pneumonia*, devised originally in Germany and later standardized by Walker in Kenya, was in its day most useful in assisting to clear up certain of the native reserves and settled areas. The development of culture vaccine against this disease was another outstanding feature of control, and between 130,000 and 400,000 doses of this vaccine are now issued from Kabete free each year. There are now extensive areas free from contagious bovine pleuro-pneumonia, and steps are being taken to eradicate the disease from the remaining enzootic areas (Walker 1929b, Kenya 1935, *D.R.*, Pt. II, p. 147). Meanwhile it is proposed to carry out a complete reinvestigation of the etiology of the disease.

The study of *trypanosomiasis* of domestic animals is in large part

dependent on that of the tsetse flies which have been considered in Chapter X. Research on the cure of the disease in Tanganyika and Nigeria has advanced knowledge materially. The drugs used have mostly been synthesized in Bayer laboratories, and extensive trials have shown that the treatment of most cases of trypanosomiasis may be attempted with a fair hope of success. Prophylactic injections of domestic animals against infection are not yet practicable, but a new compound 'Surfen C', not antimonial, has given the most promising results.

Attempts have been made in various parts of Africa to work out some process of immunization of cattle and human beings. Progress towards this end has been made particularly by Professor Claus Schilling, Director of the Robert Koch Institute in Berlin, who has continued since the war to visit Tanganyika at intervals for research, receiving facilities at Mpwapwa. Building on the natural potentiality of young game animals and some breeds of cattle to establish complete resistance as a result of repeated infection with trypanosomiasis, he has worked out a process in which the young susceptible cattle are subjected to repeated and increasing doses of trypanosomes. The process has been patented, but is offered for use free to the German Government and to Tanganyika. The results are summarized in English in two papers (Schilling 1934 and 1936b).

In addition to the major diseases, considerable advances have been made in the etiology of less important troubles such as malignant catarrh, turning sickness, para-typhoid, measles in calves, sweating sickness, sterility, contagious abortion, anthrax, and bovine haematuria.

A number of *sheep diseases* formerly acted as limiting factors to sheep farming in East Africa, and research has been carried out especially on Nairobi sheep disease (Daubney and Hudson 1931a, 1934), rift valley fever (Daubney and Hudson 1931b, 1933), heartwater, parasitic worms (Daubney 1928, Hudson 1934), respiratory diseases, streptothricosis and pulpy kidney. *Horse-sickness* has likewise been investigated (Walker 1931). In *pigs* considerable progress has been made with East African swine fever and swine influenza, and in *poultry* fowl typhoid, Newcastle disease, and roup occupy the foreground.

In Uganda special interest may be attached to recent work on *tuberculosis* of cattle and small stock. In Chapter XVI, where human tuberculosis is discussed, it is pointed out that evidence goes to prove that this disease is not indigenous to Africa, and that its effects on African natives are, therefore, often far more serious than on Europeans. This was thought to be true also of bovine tuberculosis. Results from autopsies in Uganda (Uganda, Veterinary, 1935, *D.R.*, pp. 6 and 18) suggest, however, that the disease may be much more common than was previously supposed. The disease is seldom diagnosed outside the abattoirs, but in carcases examined in the Kampala native market, 41 per cent in a lot of 464 Ankole cattle had lesions, against only 1 per cent in 1,334 zebu cattle. Sheep and goats in Ankole were also affected in a smaller degree. Later on the double intradermal tuberculin test proved positive in 76·6 per cent in a lot of 205 Ankole cattle, and only 5·2 per cent in 121 Kigezi cattle. This and other laboratory work suggest that zebu cattle are more resistant to a local bovine strain of the tubercle bacillus than are those from Ankole, while both breeds are equally susceptible to a type bovine culture of European origin. The bovine type of bacillus has been isolated from a few cases of human pulmonary tuberculosis, after a history of keeping cattle in each case. Studies are also continuing in Uganda on east coast fever, but the lack of an entomologist in the veterinary department renders this and work on trypanosomiasis difficult.

WEST AFRICA

In West Africa, although most of the diseases are similar, the problems of control are in many ways different. In the first place there are practically no introduced European breeds, and secondly, as pointed out above, most of the cattle-owning tribes, such as the Fulani of Northern Nigeria, have a more commercial attitude towards their stock. They are therefore willing to sell surplus animals for cash, and consequently there is practically no overstocking. Since the main stock markets lie to the south along the Guinea Gulf, where cattle cannot be kept on account of tsetse fly, the prevention of losses from disease in transit through the dangerous belts of the country presents a special problem. Formerly

mortality during transit was estimated to be almost 50 per cent, and serious situations resulted from the spread of disease along the routes, but in recent years this high death rate has been reduced almost to nil by a system of health tickets and by inoculating every animal before the beginning of the journey, by limiting the use of cattle tracks to a few which are known to be kept clear of tsetse, and by a series of inspection centres along each track where any animals added to the herds in transit are likewise vaccinated. (Nigeria, Veterinary, 1935 onwards, *D.R.*)

Rinderpest is the disease which has absorbed most of the energies of the veterinary departments. The policy, as in East Africa, is to immunize young animals wholesale while they are still healthy. At the veterinary laboratory at Vom, in Northern Nigeria, very large quantities of serum and vaccine are prepared. In 1936 the figures were sero-virus—382,732, spleen-vaccine—274,157 and serum alone—5,221. (Nigeria, Veterinary, 1936, *D.R.*) The serum double inoculation method, which gives an immunity amounting to lifetime when injected into adult animals, is favoured in Nigeria. The serum cannot be made, however, for less than one shilling per dose, and its use is always followed by a mortality from other diseases, mainly trypanosomiasis, as a result of weakness when the rinderpest symptoms make their appearance. This mortality was formerly as high as 20 per cent, but has now been reduced to about 3 per cent. The cattle owners willingly suffer an initial mortality for the sake of the eventual immunity of their herds. Both the Fulani and Hausa bring their herds without any persuasion to the immunization camps, of which there were some fifty-seven operating in 1936, and where the cattle are kept in quarantine for a month. The laboratory at Vom has been unable to obtain locally the requisite number of bulls for the preparation of serum and virus, and hence secondary centres under the Native Administration have had to be started at Kano, Sokoto, and elsewhere in the Northern Emirates (plate vii).

The spleen vaccine, which can be made far cheaper than the serum, has proved to give immunity for only nine months or so, and hence is not favoured by the cattle owners. It has proved very valuable, however, in immunizing cattle on their way to the southern markets, and every animal entering Nigeria from the adjoin-

ing French territories is immunized with spleen vaccine at quarantine stations. Similarly in the Gold Coast, rinderpest is now kept completely under control by a system whereby all stock entering the country from the French Sudan is immunized at the frontier. The serum and vaccine is made at Pong-Tamale.

For *black quarter* some 430,125, and for *contagious pleuro-pneumonia* some 117,543 vaccinations were made in Nigeria in 1936, usually at the same time as rinderpest. It is still something of a mystery why east coast fever has never reached West Africa in view of the cattle movements back and forth through the Sudanese regions. Presumably some ecological factor serves as a natural control, and it is often suggested, for instance, that ticks cannot withstand the long dry season of West Africa, but, as mentioned in Chapter X, among other ticks collected at Pong-Tamale in the Gold Coast were specimens of the vector of east coast fever. Regular dipping, which is so important in East and South Africa, is of much less consequence in the West, although certain tick-borne diseases such as redwater make their appearance in epizootic form at intervals. Mr. Stewart at Pong-Tamale, in investigating the blood parasites of cattle, has brought to light several forms of Theileria closely related to *T. parva* of east coast fever. One of these is the cause of a turning sickness similar to that of East Africa (Gold Coast, Veterinary, 1935–6, *D.R.*).

Trypanosomiasis is undoubtedly the most important cattle disease in West Africa. In Nigeria, for example, it has been estimated that in the Northern Territories 33 to 40 per cent of cattle carry the disease, although it usually only breaks out when the animals' vitality is reduced by rinderpest, inoculation or poor feed. In the Southern Territories right along the Guinea Gulf there is little doubt that every head of the dwarf immune cattle mentioned above carry the trypanosomes. It is certain that many distinct strains of trypanosomes exist, and that immunity to one does not involve immunity to another. Thus, herds which are immune in areas where *G. tachinoides* is the prevalent tsetse fly have been known to suffer up to 100 per cent deaths when moved into *G. morsitans* areas. Again the herd of shorthorn cattle introduced from the Gold Coast to Ilorin, although completely immune in their own home, suffered severely in Nigeria, but in this case factors of other

diseases may have been contributory in reducing resistance. In Nigeria the veterinary department has no entomological side, while the Gold Coast department has paid special attention to flies and fly control, as mentioned in Chapter X.

In the French territories the two most important cattle diseases are rinderpest and contagious pleuro-pneumonia. Serum and vaccine against rinderpest are prepared at several centres, especially at the central veterinary laboratory at Bamako in the French Sudan, where researches contributed materially to working out the original formula for rinderpest vaccine, now used all over the world. Regarding tuberculosis it is important that, whereas five years ago the bovine disease was practically unknown in the French Sudan, now between 3 and 5 per cent of cattle slaughtered at Bamako show its symptoms. Many contributions to knowledge of African diseases have been made by this and other laboratories, especially by M. G. Curasson, now Inspector-general for veterinary services in French West Africa. The research laboratories of the animal husbandry service of Morocco, at Casablanca, have likewise assisted materially in the study of diseases which affect large parts of Africa, especially the external and internal parasites of sheep; the chemical therapy of piroplasmosis and trypanosomiasis has also been advanced there.

In the Belgian Congo the two Government veterinary laboratories at Kisenyi in the north of Ruanda and at Gabu in Kabali Ituri have, like others in Africa, been engaged in preparing anti-rinderpest and other sera and vaccines. In research the Kisenyi laboratory has been concerned especially with attempts to discover a vaccination for trypanosomiasis. As in other parts of Africa, success cannot yet be recorded, but the Kisenyi laboratory is still optimistic (Congo Belge 1934 onwards). Helminthiasis in sheep is another subject which has been specially studied on the Nioka farm and at the Kisenyi laboratory, and is the subject of a special report.

In concluding this discussion, it may be stated that certain diseases have yet to be eliminated or much reduced before permanent improvement in animal husbandry can be brought about, but the influence of nutrition in resistance to disease is also important. Many diseases of stock, as of man, are known to be due to deficien-

cies in diet, and recent work on intestinal worms has shown that susceptibility is reduced by improved diet, though in some infections it has to be remembered that modern methods in which well-fed animals are herded together on improved pasture may increase the opportunities for the distribution of parasites. Nutrition is also of great importance in the cases of dormant infection: for example, the breeds of native cattle which are usually immune to trypanosomiasis carry trypanosomes in their systems when in infected areas, and a reduction in the quantity and quality of their food often leads to the parasites getting the upper hand. For these reasons the study of African pastures, much of which forms part of the work of departments of veterinary research or animal husbandry, has been described in some detail in Chapter VI.

HIDES AND SKINS

The trade in hides and skins from various parts of Africa offers considerable scope for improvement and expansion. Certain prevalent insect or fungal parasites, though not seriously affecting the vitality of their host animals, do great damage by penetrating or affecting the skins and thereby reducing their market value. For example, bot-flies damage cattle hides by their boring action on escaping from the tissues below the skin, and the value of goatskins is much reduced by the borings of the mite, *Demodex folliculorum*. For the control of the latter special research appears necessary, since dipping and other established practices have no effect on the parasites. Opportunity is thereby offered for improving the hide and skin trade by direct control of parasites.

An easier and more far-reaching means of increasing the value of hides is by improving the methods of flaying and drying. In many parts of Africa hides are seriously cut in the flaying process and are subsequently dried in the sun, which means that high-quality leather can never be produced from them. Accordingly efforts are being made by many agricultural and veterinary departments to institute systems of shade-drying and better flaying. In this the local departments have received help and co-operation from the hides and skins committee of the Imperial Institute, and from the British Leather Workers Research Association.

In some territories the trade in skins is responsible for large exports; this is so particularly in Nigeria, where a scheme is in operation throughout the Northern Provinces and more recently also in parts of the Southern Provinces for the better flaying and drying of hides and skins, and already a big improvement in quality, with an increased price, has resulted. The development of the export trade in goatskins, especially the red Sokoto skin which has a high reputation on the European market for book-binding and other high-class leather goods, is of particular importance to Nigeria. An attempt to improve the Nigerian goats by imported Alpine stock from Great Britain failed, as the hides proved inferior and more susceptible to some skin diseases. An experiment is now being carried out in Sokoto Province designed eventually to eliminate all goats other than the pure red (Nigeria, Veterinary, 1935 and 1936, *D.R.*); male goats of other colours are being castrated in large numbers and males of the pure red breed are being issued for stud purposes by the native administration. There is a difference of at least sixpence between the price paid for the skin of a pure red goat and that of any other colour. Approximately 5,000,000 goatskins are exported annually from Nigeria at prices from two shillings to three shillings and sixpence per skin, so it is clear that any increase in price even of only a few pence would produce an appreciable improvement in revenue. It is worth noting that the small thin skins are the most valuable, so that the breeding of goats for their skins entails a reduction in their meat and milking capacity. Local tanning may likewise offer opportunities for development, since the native method carried out with Acacia bark and pigeon dung appears to withstand European conditions better than the chemical tanning methods in general use. The damage to skins in storage by beetle has been mentioned in Chapter X.

PRESERVATION OF MEAT FOR MARKET

With the extension of animal husbandry in Africa, it has been necessary to develop means of preservation for storage and transport. The African climate involves special conditions in this respect, so that research on the most suitable methods has proved

necessary. The preservation of meat is in some ways similar to that of fish (considered in Chapter IX), and the methods can be divided into those involving drying and smoking, the use of low temperatures, and tinning. The drying and smoking of meat into biltong is easy in most African climates and is a method of preservation very widely used by African peoples, and formerly by the Dutch in South Africa, but with the development of export markets it will probably give place to other processes. In Nigeria, where the principal markets in the south are so far from the cattle-breeding areas of the north, Captain Henderson, chief veterinary officer, is trying to establish a market for dried or salted beef, the transit of which would be so much easier than cattle on the hoof. At present the Africans do not appreciate dried meat; salted beef has better prospects, but the process of curing is not yet perfected.

The need for a cheap and simple method of preserving meat is widely recognized. For example in Uganda, although meat is smoked in some areas, the method does not preserve it for any length of time. It has been suggested that a simple piece of research is required to demonstrate that the use of a suitable preservative fluid prior to smoking would keep the meat in a good condition for some time, and that the large canoe-shaped wooden receptacles, used for brewing beer, would make admirable tubs for the immersion. The introduction of such a method might stimulate the slaughter of surplus stock and a greater consumption of meat by agricultural tribes. In Uganda the number of cattle has increased so much in the Eastern Province that a large supply will be available in a few years' time. Perhaps a factory might be established at some place on the railway, such as Tororo, where land might be acquired for paddocking and suitable pastures might be grown to fatten the best beasts for an export trade.

Regarding the use of low temperatures, a considerable amount of chilled beef is exported from South Africa and Rhodesia, and now that it is becoming recognized that the future of so much of these countries lies in animal husbandry rather than in grain produce, the meat exports are likly to increase yearly. The principal centre of the industry in the Union is Johannesburg, where an expert, employed by the municipality, maintains close contact with the Onderstepoort laboratory. At Onderstepoort a new

branch to deal with cold storage and other questions relating to the preservation of meat is being developed. A building is being erected (1936) at the probable cost of about £32,000, and will consist of three sections: (1) an abattoir, containing on a small scale all the modern equipment for handling and slaughtering cattle, sheep, and pigs. This will be used to study methods of killing and handling the carcases so as to determine the best conditions for the preservation of meat; (2) a cold storage section, which will include chambers equipped both for chilling and freezing, and in which temperature, humidity and aeration will be controlled. These will be used to study the optimum conditions under which meat, eggs, and dairy products should be kept, and provision will exist for studying gas preservation if necessary. A special section of the cold storage plant will be used for the storage of vaccines, sera and specimens, and very low temperatures will be available for the preservation of viruses, etc.; (3) a meat research section, including laboratories for physical, chemical, histological, pathological, and bacteriological examination of meat.

In Southern Rhodesia the centre of the meat industry is at Bulawayo, where the Imperial Cold Storage Company has its headquarters. Administration and research are centred at the department of agriculture, Salisbury. Each of these organizations in South Africa and Rhodesia maintains contact with the Low Temperature Research Station at Cambridge, which is the principal centre for research on the preservation of meat in England.

The necessity for opening markets for native-grown beef in many parts of Africa, in connection with the overgrazing problem, has led several authorities to stress the desirability of meat factories (Smith 1937). In Tanganyika one such factory was started at Mwanza (*see* Chapter XIII), but after a few years it had to be closed down. In 1937, Messrs. Liebig started a meat factory at Athi River in Kenya (*see* page 422). The extension of such activities will naturally raise fresh problems for research in the best methods of making and canning meat extracts in tropical countries.

DAIRY INDUSTRY

In the *Union of South Africa* dairying is a considerable industry. Cattle can thrive on the natural veld for six or eight months of the year in districts where the rainfall is good. Fodder crops grown for dairy cattle include maize, lucerne, oats, teff grass, millet, mangolds, rye, and cowpeas. The number of European owned cows and heifers of over two years old was 2,150,471 in the census of 1936. Many excellent herds of pure-bred cattle are maintained. Creameries and cheese factories have played a large part in the development of the dairy industry, and, since the war especially, their production has rapidly expanded. Butter production by the creameries, which in 1927 amounted to 14,132,000 lb., had risen in 1936–7 to approximately 31,800,000 lb.; the factory production of cheese, which in 1927 was 6,001,000 lb. reached 11,200,000 lb. in 1936–7. Registered creameries now number 58, and cheese factories 116. Figures for milk production are not available, but great improvement has recently been made, in both quantity and quality.

The division of dairying of the department of agriculture and forestry, maintains officers in each of the four provinces, and their functions include advice and instruction to farmers. Butter and cheese for export have been compulsorily graded since 1917; whilst in 1927 a comprehensive milk recording system was inaugurated, milk recording having proved a great stimulus to breeding. Under this scheme a test is made for the solids-not-fat contents of the milk registered cows. Since 1930, in order that supply and demand may be more equitably adjusted, a dairy board of control has been instituted, on which, under the chairmanship of the superintendent of the division of dairying, the various interests of the industry are represented; the board makes use of a system of levies and bounties; it also advises concerning registration of creameries and cheese factories. The board makes grants towards research and milk recording. A state aided butter and milk scheme was commenced in 1935, with the object of increasing internal consumption of these products; it consists in the supply of milk to school children, or where milk is unobtainable, cheese, and the supply of butter to certain classes of low wage earners and

to charitable institutions at special rates. The social value of the scheme is apparent.

The Dairy Research Institute attached to the University of Pretoria is maintained jointly by the university and the division of dairying and besides ordinary routine work research is conducted. Projects under investigation include the processing of cream by the 'Murray vacreator' and the 'A.P.V. pasteurizer and degasser' for manufacturing butter; work on surface taint in butter; chemical tests for detecting rancidity in butter, the relationship between mastitis infection of the cow's udder and the solids-not-fat content of milk; studies of the metabolism of proleolytic organisms causing bitterness in dairy products; the manufacture of cheese from pasteurized milk, and studies of the defects, fattiness and oiliness of South African butter. Dairy research work is also done at the Potchefstroom, Cedara and Glen schools of agriculture, and at Stellenbosch University. The number of dairy research workers in the Union was eight in 1937 (Imperial Agricultural Bureaux 1938).

In the *High Commission territories*, cream is produced in the south-western part of Swaziland, for the creamery at Port Relief. Native dairies are on the increase, and a larger number of milk collecting stations will be established as the newly constructed Bremersdorp butter factory comes into operation. In Bechuanaland two creameries were registered with the Union dairy control board in 1936.

In *Southern Rhodesia* the encouragement of the dairy industry as part of a general policy of establishing mixed farming was recommended by the report of the committee on agriculture (Southern Rhodesia 1934). The industry has a dairy control board as in the Union, and some eight registered creameries produce over a million pounds of butter annually. Efforts to reduce the proportion of lower grade cream are meeting with success. Research is conducted by the chief dairy officer.

In the *Anglo-Egyptian Sudan* a certain amount of clarified butter is produced. In 1936 the veterinary department started the collection of data from centres with a seasonal surplus of milk, with a view to establishing creameries and thereby encouraging the industry; the simple method of preparation direct from cream,

which has been tried in Tanganyika, was also under investigation (Anglo-Egyptian Sudan, 1936, *D.R.*).

In *East Africa*, dairying has become a distinct branch of the European cattle industry of Northern Rhodesia; the number of suppliers of the co-operative creamery at Lusaka rose from 63 in 1935 to 78 in 1936, and the amount of butter manufactured rose from 146,029 lb. to 206,052 lb. in the same period. Native participation is still very small; one centre, a mission station, collects cream from them. The possibilities of establishing a native ghee industry are receiving attention. In Nyasaland, an interesting demonstration of the value both of good animal management and of feeding clean milk to children, is being undertaken by the veterinary in conjunction with the medical department; milk, purchased by the government from cattle-owners who comply with specific instructions for the care of their cattle, is supplied to a certain number of school children in addition to their ordinary diet. It is hoped that the results will prove a valuable ocular demonstration. In Tanganyika a demonstration on somewhat similar lines consists in the supply of milk to boys of the Mpwapwa school from the veterinary department's farm there. As part of the general policy of increasing the milk supply, experiments with milking goats have been undertaken, but have so far failed owing to the increased susceptibility to worm infection which accompanied improved milk yield. Clarified butter (ghee) is manufactured under the supervision of the department at ten factories in the Central and three in the Western Province, which are opened temporarily during periods when there is a milk surplus; in 1936 the output was 30·4 and 4·2 tons respectively. A flourishing ghee industry, under private management, has grown up in the Musoma area of the Lake Province; the quality of the ghee, though below the uniformly high standard required of factory-made certified butter, is good, and in 1936 some 700 tons were produced, which is thought to be practically the limit of production (Tanganyika, Veterinary, 1936, *D.R.*). The industry is given help and advice by the veterinary department; in 1936 a new method of production by boiling the cream direct to ghee without previous churning, was introduced; it has been described in a paper by the chemist (French 1936). In Kenya the ghee industry is also encouraged

by the veterinary department during the brief periods of abundant rainfall when milk is plentiful; dairy units are provided at suitable centres, and consist of a churn, separator, and accessory equipment housed in temporary or permanent buildings. The question of attaining a standard quality is under investigation, for without the guarantee of such a standard, export is difficult. In 1936 the total number of dairies established was 772 and their production of ghee approximately 10,000 cwt. In the European areas, butter and cheese are produced; in 1936 24,983 cwt. of butter was exported. (Kenya 1936, *D.R.*) In Uganda the production of ghee is also encouraged by the veterinary department through a series of posts and demonstrations mainly financed from Native Administration sources. As in other territories, care is taken that only surplus milk shall be so utilized. An interesting scheme is the production of good quality butter at a centre in Bugishu, first sponsored by the veterinary department and since taken over by private persons.

In *West Africa* the veterinary department of Nigeria first encouraged the manufacture of ghee in 1932 by establishing buying-posts, through which central depots for dairying and packing were supplied. The industry has now been taken over entirely from the department by the United Africa Company, which has erected two factories, one at Kano and the other at Jos, where butter bought from native cattle-owners is rendered down into fat; the method of manufacture is the same as that at Vom. Additional butter-buying centres are being opened in seasonal cattle-grazing areas. In 1936, 547 tons were exported as compared with 321 tons in 1935, and it is estimated that with the trade properly organized, exports should soon attain 1,000 tons (Nigeria, Veterinary, 1936, *D.R.*), In the *Belgian Congo* European farmers produced in 1936 55,458 kilos of butter and 3,943 kilos of cheese.

The *Journal of Dairy Research*, published triennially in Great Britain, besides giving original papers, reviews and summarizes progress in dairy research.

CHAPTER XV

HEALTH AND MEDICINE—GENERAL

INTRODUCTION

CERTAIN general considerations regarding medical policy are necessary in order to indicate the close relation of health and medicine to other subjects. In Africa, as elsewhere, much of medical activity in the past has been devoted to the treatment of disease rather than the promotion of health, and there has been a tendency to separate work into categories such as curative medicine, preventive medicine, and other social services. To-day, however, expert opinion appears to be in agreement as to the close interdependence of all aspects of medicine, though expediency must sometimes dictate the creation of arbitrary divisions. From this point of view the medical policy, especially in rural Africa, must be considered in relation to (1) the causes of disease and disability (2) the protection of individuals and the community, from these causes, and (3) the provision of adequate living conditions whereby health may be maintained. Emphasis on any one of these aspects cannot produce permanent beneficial results unless proportionate attention is devoted to the others. For example, an improved standard of living, embracing such desirable features as adequate and balanced diet, good housing and water-supply and sound agricultural development, cannot alone protect the community from disease. On the other hand, the study of the major tropical diseases has now advanced to a point where nearly all are curable, so that many authorities now urge that increasing attention should be devoted to the preventive aspects of medicine, and the development of social services. Dr. A. R. Paterson (1928b) in Kenya, Dr. Kauntze (1935) in Uganda and many other authorities have emphasized the great importance of housing and sanitary conditions.

It is apparent that the policy of any medical department should be closely co-ordinated with other government and mission activities directed to the development of native society. In particular it cannot be over-emphasized how great is the importance of a thorough knowledge of tribal custom and native attitudes. The improvement of social conditions depends largely on the introduction of measures in a manner which meets with general approval and not with passive resistance. Hence the order of introduction of social measures among different tribes may have to be varied on account of their different traditions. Divergences of organization are inevitable even in one territory, and while approval may be given to a general plan for social amelioration, the detailed mode of execution must be left to those with intimate local knowledge. It is therefore imperative that administrative officers, who in the end are the men responsible for the social welfare of their people, should have that ability to obtain and maintain the confidence of the people under their control which comes only from such knowledge.

Since proposed measures of hygiene are apt to be viewed with indifference unless they can be shown also to have economic advantages, as in the case of the use of manure and domestic refuse as soil fertilizers, the co-operation of medical and agricultural workers is important, and calls for deliberate organization. Public works construction, education, forestry, and water-supplies may also have direct bearing on questions of native health. Indeed every activity of government is involved.

The necessary co-operation might be attained through social development committees consisting of the heads of the various departments concerned, which would secure a co-ordinated expansion of social services. An example of this form of development is the Nyasaland Native Welfare Committee, set up in 1935, and including representatives of the administrative, medical, education, agriculture, and forestry departments. Another way would be to follow the system adopted in India and elsewhere of appointing a secretary to government who would be responsible for all departments dealing with the social services (*see* Chapter I).

The importance of health and medicine in all parts of Africa makes it necessary to devote a large part of this volume to the

subjects involved. This chapter is concerned primarily with systems of organization of services, the next with diseases, and Chapter XVII with general questions such as rural hygiene, vital statistics, and nutrition.

ORGANIZATION

INTERNATIONAL

International work in health and medicine is more fully organized and more important to Africa than in other scientific subjects, and must be considered before work in the separate dependencies is described. The two principal co-ordinating bodies are the Office International d'Hygiène Publique in Paris, and the Health Section of the League of Nations centred at Geneva.

The *Office International d'Hygiène Publique*, created under the Rome Agreement of 1907, has an official (governmental) permanent committee representing fifty-three nations and including delegates from a number of African territories, with a secretariat in Paris. Its total cost has been in the neighbourhood of £22,000 per annum, of which some £9,000 is spent on staff. Its activities cover a wide field, but are concerned primarily with the prevention of particular infectious diseases by international sanitary conventions. That of 1926 dealt with several formidable epidemic diseases, and more recently the International Convention for the Sanitary Control of Aerial Navigation of 1933 is of special significance for Africa in view of the danger of diseases such as yellow fever, which are endemic in one part of the continent, spreading to other parts.

The *Health Section of the League of Nations* is more recent in origin. Article 23 of the Covenant provides that 'Subject to and in accordance with the provisions of international conventions existing or hereafter to be agreed upon, the members of the League . . . will endeavour to take steps in matters of international concern for the prevention and control of disease.' Under this power a health organization was created in 1923 which now consists of a General Advisory Health Council (which has the same membership as the Committee of the Office International d'Hygiène Publique), a Standing Health Committee, and a Health Section of the League

Secretariat. The annual budget of this organization amounts to almost £63,000, of which some £40,000 is spent on staff. The work carried out under its auspices on such subjects as sleeping sickness, tuberculosis, leprosy, and public health services has been of great value to Africa, and several publications on these subjects (referred to later) embody reports of the different international commissions organized by the League. Though the work of the Malarial Commission in particular has so far been concerned primarily with European countries, the conclusions reached will be applicable throughout the world.

Another valuable organ of the Health Organization is the Permanent Commission on Biological Standardization. An intergovernmental conference on this subject was held at Geneva in 1935 and had, as its main object, the making of the international standards better known and the encouraging of the various countries to establish national centres for the distribution of standards. Already the influence exerted by this conference is resulting in action; for example, in South Africa a new biological control laboratory has been established in Capetown for work on the standardization of vaccines, sera, etc.

International conferences are organized from time to time: the health conferences of 1932 and 1935 are mentioned below. The results of such activities are published in the *Quarterly Bulletin* of the Health Organization. The three-monthly *Epidemiological Reports* and the weekly *Epidemiological Record* include vital statistics from many countries, and valuable data from some of the African territories are available in them. Dr. Mackenzie, a member of the Health Organization, twice visited Liberia to study public health problems (1932b), and a health survey of the population was made by Dr. L. Anigstein (1936a, b and c; 1937a and b).

The *International Conference of Representatives of the Health Services of African Territories and British India*, held at Capetown in November 1932 under the auspices of the League of Nations and the Office International, has promoted relations between medical departments in adjacent territories and improved co-operation in the several medical subjects. It was attended by representatives of all the principal British territories, and of Angola and Mozambique, but unfortunately the French and Belgian colonies were not

represented. The principal subjects discussed were yellow fever, plague, smallpox, leprosy, rural hygiene, dengue, and the transmission of diseases by aircraft. On nearly all these subjects, notably in the cases of yellow fever, plague and aircraft transmission of diseases, new developments, calling for action by public health authorities and having international importance, were deemed to need attention in the near future. A *Pan-African Conference* was held at Johannesburg in November 1935, being attended by representatives of the French Colonies and the Belgian Congo in addition to those mentioned above. Further discussions took place on hygiene and medical services in rural areas, the provision of medical services for natives, the training of native medical subordinate personnel, protective measures against the introduction of yellow fever, preventive measures against plague, typhus and other diseases, and research in animal diseases. Reports of these conferences were published by the League of Nations (1933b and 1936).

The *International Health Division of the Rockefeller Foundation* has been connected with Africa chiefly through its work on yellow fever. Many of the advances in knowledge of this disease have come from the Commission of experts which established a laboratory at Yaba near Lagos in 1925, and worked there until 1933, after which the laboratory was taken over and extended by the research branch of the Nigerian medical department.

Of importance in connection with port health work in the Union of South Africa and all territories with ports on the east coast is the *Epidemic Intelligence Bureau at Singapore.* This bureau was established after a conference at Singapore in 1925 representing governments and sanitary organizations in the Far East, held under the auspices of the League of Nations. The Rockefeller Foundation contributed approximately £5,000 a year for a period of five years for the purpose. The bureau receives telegraphic reports regarding epidemic diseases from all countries in the eastern area including the east coast of Africa and the Union, and it transmits by telegraph or wireless from Saigon a weekly summary in code to all countries concerned.

The *International Missionary Council*, situated in London, is composed of representatives of a large number of Protestant missionary

societies. Though medical work is only a small part of missionary activity, the number and standard of hospitals and health centres supported by missions make some mention of this body essential in any survey of international organizations interested in health questions in Africa.

The control of epidemics calls for a considerable degree of international co-operation. The danger from air transport, which is now fully recognized, is discussed in a later section on yellow fever. Other forms of transport, such as rail and motor, are easy to control, but the spread of epidemics by travellers on foot presents more difficult problems. It has been emphasized by some experts that international organization falls short in this respect and that the question is of special importance in those parts of Africa where natives continually cross the numerous frontiers to trade or seek work. Successful control depends on the immediate notification of disease outbreaks from territory to territory, supplemented by a system of medical passports recognized on both sides of the boundary. International notification has been in force in West Africa for about the last twelve years, but has not always worked satisfactorily. Wireless communication offers opportunities for advance in this respect, and is already in use, especially at the chief ports in connection with shipping and port health work. There seems to be scope for an enlargement of these services on an international footing, to provide a system of wireless communiqués which would be picked up by health services and ships along the coast. A precedent for this already exists in the Singapore epidemiological broadcasts mentioned above.

Existing regulations regarding medical passports in Africa do not as yet achieve their aim in all cases. Along certain frontiers conveniently situated for administrative control, every native has to carry a paper concerning the state of his health, but it appears that these passports are not always recognized in the neighbouring country, and there are wide stretches of frontier where no such control yet exists. As an example, a medical passport system has been established on the border between Uganda and Tanganyika west of Lake Victoria, in order to prevent the northward spread of the *rhodesiense* type of sleeping sickness. Here the Kagera River, which forms the frontier, can only be crossed at four points where

there are ferries which can be easily controlled. On the other hand, on the border of Uganda adjoining the Belgian Congo in the Busongora area, where the Lubilya River is easily crossed at any point, control is difficult if not impossible. The Congo government will not permit immigration from Uganda without a certificate that the immigrant is free from sleeping sickness, but in view of the fact that people on both sides of the border are members of one tribe and go constantly to and fro to see friends and relations, control by this system is probably impossible without a large staff of inspectors.

BRITISH

Before outlining the systems at work in the dependencies separately, institutions serving the British Empire as a whole must be considered.

The *London School of Hygiene and Tropical Medicine* is a training-ground for colonial workers, and a centre of research in entomology, protozoology, and helminthology, as well as in clinical medicine, while the recent incorporation of the Ross Institute has added a section for the study of practical measures for the control of tropical diseases. The teaching staff are enabled to keep in close touch with field progress by contacts with colonial officers on leave, and sometimes by visits to the field. For instance, Professor P. A. Buxton, head of the Department of Medical Entomology, paid a visit to Nigeria in 1933 for research on tsetse flies (*see* Chapter X); the late Professor J. G. Thomson, when head of the Protozoological Department, spent part of 1934 in Nyasaland; Dr. K. E. Mellanby and Mr. Leeson went to Uganda in 1935 and 1936 respectively, and Dr. Jameson visited the Sudan and Uganda in 1937.

Attached to the school is the *Bureau of Hygiene and Tropical Diseases* under the direction of Dr. Harold H. Scott, which is maintained by the Colonial Office, and has as its principal function the collection, from all sources, of information on hygiene and tropical diseases. It collates, condenses, and, where necessary, translates the information, and makes it available by means of two monthly periodicals, the *Tropical Diseases Bulletin* and the *Bulletin of Hygiene*, in which abstracts of all the important technical papers

are published. From 1931 onwards a valuable Supplement to the *Tropical Diseases Bulletin* has been published, consisting of summaries by Dr. Scott of the medical and sanitary reports from British colonies, protectorates, and dependencies. The bureau is under the general control of an honorary managing committee appointed by and responsible to the Secretary of State for the Colonies. The other sources of information are the *Imperial Bureau of Agricultural Parasitology* (*see* Chapter XI), which abstracts the literature on medical parasitology, and the *Bureau of Nutrition* at the Rowett Institute, Aberdeen.

The *Liverpool School of Tropical Medicine* is another important headquarters of training and research, especially in relation to the West African colonies. This school has sent many expeditions to Africa, and it maintains and staffs the Sir Alfred Jones Laboratory at Freetown, Sierra Leone, an independent institution, the Director of which is consulting pathologist to the Government. It has a European staff of two, occasionally increased to three or four, who have set out to make a survey of several of the main diseases and parasites of equatorial West Africa as a whole. Visiting research workers often use the Sir Alfred Jones Laboratory as an headquarters; for example, Mr. Davis, formerly attached to the Bureau of Animal Populations at Oxford, recently conducted a census in Freetown of rats and their parasites in relation to plague and tropical typhus.

The *Medical Research Council*, with an allocation of government funds, finances or assists numerous researches in Great Britain. Among those which have bearing on African development are the following: the Experimental Malaria Unit under Sir Rickard Christophers, maintained at the London School of Hygiene and Tropical Medicine for the study of antimalarial drugs; work of a similar nature at the Molteno Institute at Cambridge; two research fellowships in tuberculosis have been devoted to work in Eastern Africa; and an inquiry into the nutritional problems of Nigeria has been assisted by the Council. As announced in their recent report for 1935–6 (1937) the Council, finding themselves in a better position than formerly to fulfil their responsibilities of research into problems of health and disease in tropical conditions, intend eventually to establish permanent posts for research into tropical

medicine, the holders of which will work partly in the tropics and partly in British institutions to which they will be attached. The first stage in this programme has been the creation of fellowships for tropical research, of which two junior and two senior have already been awarded in 1938. This enlargement of the Council's work has followed on the establishment of the Tropical Medical Research Committee (*see* below).

The *Colonial Office*, where Dr. A. J. R. O'Brien is Chief Medical Adviser, has a great interest in colonial medical developments. The Colonial Advisory Medical Committee keeps in close touch with the individual services by the examination of annual medical reports, by interviewing officers on leave, and in other ways. In 1934 the Colonial Medical Service was constituted as a unified service, a change which, among other advantages, has rendered the transfer of officers from one dependency to another easier and more frequent (Colonial Office 1936a). Special advisory committees on specific problems are set up by the Colonial Office; for example, a Colonial Nutrition Committee was appointed in 1936, which includes representatives of many interested bodies in Great Britain, and a general inquiry into available information on food supplies and native diets in the dependencies was set on foot (Colonial Office 1936b).

The *Tropical Medical Research Committee*, established in 1936, was formed as an advisory body, including representatives of the Medical Research Council, Colonial Office, and the Liverpool and London Schools of Tropical Medicine, to institute a wider programme of research in the tropics. A similar organization, the Colonial Medical Research Committee, was established in 1927, but it proved inconvenient from the administrative point of view and was dissolved at the end of 1930, and its functions merged in the Colonial Advisory Medical Committee.

Medical Missions are organized by nearly every branch of the Christian Church and have contributed greatly to the improvement of the general health in many parts of Africa. There is a British Advisory Board on medical missions in London. The staff of these missions are men and women of immense energy, skill, and resource; some have built up well-equipped hospitals, and others have concentrated on the preventive and educational side of

medical work, and have deliberately preferred hospitals of a type not far removed from native life. To mention a few examples among many, the well-known C.M.S. hospital at Mengo, Kampala, was built up through the work of Sir Albert and Lady Cook. It is one of the earliest hospitals in East Africa, dating from 1896, and is now among the largest, having 163 beds and some 16,000 out-patients annually, but perhaps its most important work is connected with the twenty-four maternity and child-welfare centres with attached dispensaries which deal with some 150,000 cases every year. In Tanganyika the maternity hospital and dispensary of the African Inland Mission at Kalandato near Shinyanga, with Dr. Maynard in charge, is another striking example of such work. In West Africa missionary activity in the Southern Provinces of Nigeria has resulted in the establishment of many medical centres, among which may be mentioned the C.M.S. maternity hospital at Iyaenu, near Onitsha, in charge of two lady doctors, where, on nearly every day of the year, a baby is born under hygienic conditions and some 200 out-patients come for consultation. As another West African example the work of Dr. A. Schweitzer in Equatorial Africa is well known through his books (1922 and 1931). In every territory where mission organizations provide an essential part of the medical facilities, co-operation with the government is established and the relationship between them is of the friendliest character. Government medical officers inspect and give all possible assistance to mission hospitals within their districts, and reciprocal visits from medical missionaries are welcomed, though the latter are so few in number that they have little time for visiting places other than their own institutions.

Private practice in many of the tropical territories is already important in relation to the health of Europeans. It has developed mainly in the large cities and some of the more closely settled agricultural areas in South and East Africa. In addition a considerable number of Asiatic doctors, mostly trained in India, are now practising in Eastern Africa, and on the West Coast, African practitioners, trained in Europe, are established in most towns. While such facilities at present reach only a very small proportion of Africa's population, the co-ordination of medical work involves the

recognition that private practice among native as well as non-native races will continue to increase.

The health work of *commercial and mining companies* deserves special mention. Mining companies employ considerable medical personnel, maintain their own hospitals and dispensaries, and thus act as centres for the dissemination of medical knowledge among their employees. As an agency for native welfare perhaps the Belgian organizations of this kind are better examples than some of the British (*see* below).

Propaganda organizations are beginning to play an important part in the improvement of public health. The cinematograph is a specially valuable instrument of propaganda and has sometimes been used as such by government departments in both East and West Africa. In Nigeria, for instance, a lorry equipped to show films was obtained for health propaganda through a grant from the Colonial Development Fund. In 1933 the Department of Social and Industrial Research of the International Missionary Council considered the possibility of research into films suitable for Africans. In 1935 the Bantu Educational Cinema Experiment was set on foot, aided by a grant from the Carnegie Corporation of New York and with the co-operation of the British Colonial Office, the East African Governments, the British Film Institute, and the International Institute of African Languages and Cultures. A report on the experiment was published in 1937 (Notcutt and Latham 1937) and contains proposals for future policy.[1]

For the purposes of the following pages, which sketch the medical and health organizations in the individual territories, data concerning staff, beds available in hospitals, numbers of patients treated and so on, have either been obtained directly from the authorities concerned or extracted from recent publications. Since these data are not all compiled on the same basis in the different territories, it would be misleading to show them in tabular form (except in the case of the Union of South Africa), and they are therefore included in the text in small type.

Union of South Africa

Medical and health work in the Union is under the general con-

[1] See *A Survey of Africa*, Chapter xvi.

trol of the Secretary for Public Health of the central government, Sir Edward Thornton. There is a full account of existing medical facilities in the Official Year Book (1937), and an interesting article by Dr. J. A. Mitchell, late Secretary for Public Health, on the history and development of the health administration in the country before and after the constitution of the Union, was contributed to earlier issues. It is difficult to give an adequate summary of the medical staff because private practice has grown to such a degree in South Africa that the hospitals, etc., rely, as in Great Britain, to a large extent on part-time work by practitioners and specialists. For certain purposes, such as the control of sanitation and outbreaks of infectious disease, most municipalities and some other local authorities have health officers and health departments attached, but the scope of these organizations varies so much, in the absence of uniform legislation, that it cannot be summarized. In most districts of the Union medical officers, mostly part-time, known as district surgeons, are employed by Government. In June 1936 there were in all 357, of whom 339 were part-time. A port health officer is appointed by the government as resident at each port of the Union for the inspection of vessels. In 1935–6 the Union government expenditure on public health, medical services, lepers, and mental diseases was £1,106,168 out of a total ordinary expenditure, excluding provincial services, of £30,135,791; general hospitals are controlled by the Provincial Administrations, which also administer poor relief.

The introduction of National Health Insurance in the Union has recently been under consideration by a Committee of Inquiry appointed by the Minister of Public Health (Union of South Africa 1936). Its principal recommendations are that compulsory health insurance should be instituted in urban areas; the number of district surgeons in rural areas should be increased, using where possible the services of local residents, and in the native areas, where medical services are quite inadequate for the needs of the population, a general extension is required, including a larger staff of doctors, the inauguration of a native nursing service, and a staff of health visitors.

Hospitals in the Union are numerous: details are shown in the following table, and in addition there are eleven institutions for

UNION OF SOUTH AFRICA—HOSPITAL FIGURES FOR 1937

(Excluding hospitals, other than for infectious diseases, where fewer than six patients per annum were treated.)

		Total: all hospitals	*General hospitals*	*Private Nursing homes*	*Maternity homes*	*Infectious diseases hospitals*	*Mine and factory hospitals*
Hospitals	Total number ..	544	150	150	139	40	65
	European only ..	260	14	113	129	4	—
	Non-European only	122	19	12	7	21	63
Beds	European	9,413	5,148	2,332	804	1,041	88
	Non-European ..	15,372	6,332	352	185	1,257	7,246
Patients treated	European	172,555	109,298	47,357	9,829	4,787	1,284*
	Non-European ..	326,128	110,082	2,445	3,527	11,897	198,177
European Staff	Matrons and trained nurses	2,372	1,235	602	271	139	125
	Probationers ..	2,768	2,019	439	140	100	70
Distribution of hospitals	Cape of Good Hope	208	70	54	52	27	5
	Natal	90	32	29	13	4	12
	Transvaal ..	196	39	43	64	5	45
	Orange Free State	50	9	24	10	4	3

NOTE.—This table is compiled from information received from the Office of Census and Statistics, Union of South Africa.

*—Includes patients of a hospital formerly treated as a nursing home.

the feeble-minded, four for venereal diseases and five leper institutions.

For research the centre is the South African Institute for Medical Research at Johannesburg. The subjects investigated here include plague and its spread by infected wild rodents, the silicosis of gold-mining, tuberculosis in natives, pneumonia, meningitis, other bacterial diseases, and tumour formation and growth. The institute has also a field research station at Eshowe in Zululand, Natal, for the study of malaria vectors. The expenditure on the institute for the year 1935–6 was £70,013. The University of Witwatersrand Medical School, which works in close association with this institute, though primarily a teaching centre, has also a research branch. The Department of Public Health has initiated research into various matters; for example it arranged for Professor Swellengrebel to organize a malaria investigation which was started in 1930 and is being continued by officials of the Union Health Department which has a research station at Tzaneen in the Transvaal; close co-operation is maintained with the similar research being done by the South African Institute for Medical Research.

The Research Grant Board of the Union, instituted in 1918, advises the government on medical and other research and administers all government grants in aid. The Carnegie Corporation of New York provides additional funds and advises on their distribution. Private practice has reached such a stage in the Union that many doctors have their own laboratories for the examination of pathological and other specimens; and recently a South African Association of Private Laboratories has been inaugurated to promote co-operation and to encourage such valuable research work as that of Dr. A. Pijper on the typhus-like diseases in Southern Africa.

In *South-West Africa* the health service includes the Medical Officer of the Administration, stationed at Windhoek, one whole-time and fourteen part-time district surgeons appointed on the same basis as in the Union of South Africa. There are five state-aided hospitals entirely for Europeans, three Roman Catholic mission hospitals for Europeans and natives; hospitals or medical stations are also maintained by the Finnish, Anglican, and Rhenish missions. There are also one or two private nursing homes at Windhoek. Apart from the work of missions and

the district surgeons, medical services for the natives appear to be restricted to three state-owned native hospitals, directly controlled by the Administration, situated at Windhoek, Keetmanshoop and Omaruru.

In 1936 there were 926 European and 1,686 non-European in-patients, and 203 European and 5,631 non-European out-patients in government institutions. These have together a total of 103 beds. Expenditure on public health in 1935–6 amounted to £22,831, out of a total ordinary expenditure of £731,802. In 1936 the native population, including coloured, was estimated at 253,090; the preliminary census figures for 1936 give the European population as 30,677.

In *Basutoland* the first medical work was that of French missionaries in 1844. The present system was built up by the work of Dr. E. C. Long, who was appointed principal medical officer in 1894 and served for thirty-two years. In 1936 there were eight[1] hospitals with twelve European and 148 native beds. That at Maseru is the largest and is ranked as a Class I hospital by the Cape Medical Council. The hospital at Qacha's Nek was in process of enlargement during 1936, the accommodation being increased from fourteen to twenty-eight beds, and a theatre equipped on modern lines was built.

In 1936, for the whole territory, in-patients numbered 3,298 and out-patients at government dispensaries 82,952, out of a total native and coloured population of about 561,000 for Basutoland. The staff consists of a principal medical officer, nine medical officers, an assistant medical officer, and one district surgeon, disposed in eight districts. There are fourteen European nurses and a considerable subordinate staff, whose work is confined at present to the hospitals. An increase in health services in rural areas has been considered desirable. A satisfactory scheme is in existence for training nurses and dispensers, but little maternity work has been done. There is a leper settlement near Maseru, started in 1914, with a staff of two European doctors, a matron, and three nurses and a population of 684 in 1936.

Health and medical expenditure in 1936 was £48,932 out of a total ordinary expenditure of £294,883. (Basutoland 1935 and 1936, *D.R.*).

In *Bechuanaland* the staff for a population of 260,064 included, in 1936, a principal medical officer stationed at Mafeking and

[1] Including the temporary hospital at Mokhotlon.

eight other government medical officers; there were also four subsidized medical missionaries and one subsidized doctor. The hospital system consisted of three government hospitals at Lobatsi, Serowe, and Francistown, each with some four beds for Europeans and twenty for natives, and five smaller mission hospitals; whilst a hospital at Maun was in process of erection by the Seventh Day Adventists, and a hospital at Sofula was projected by the London Missionary Society. Both the projects were made possible by grants from the Colonial Development Fund.

> There were in 1936, 1,751 hospital in-patients and 70,933 attendances, of which 27,196 were first attendances at government and medical mission hospitals and out-stations. Government health services accounted for an expenditure of £20,126 out of a total for the Protectorate of £167,310 (year ending March 1937). Medical mission work is subsidized to a small extent. The native population was given as 260,064, Asiatic 66, coloured 3,727, European 1,899.

Sir A. W. Pim (Bechuanaland 1933) commented on the insufficiency of the service, especially in the west and north of the territory, where practically no medical assistance existed, and recommended the extension of dispensaries and the training of native nurses and other subordinate staff. A sanitary inspector has since been appointed for work in village conditions. A special grant from the Chamber of Mines was made for the training of native nurses and dispensers in 1935, and by 1936 the scheme was in operation. In order to make medical facilities available in some of the outlying parts of the protectorate two travelling dispensary units, each consisting of two lorries, a medical officer, European chauffeur-mechanic, native dispenser-interpreter, and native driver, were put into commission during 1936; total attendances at them numbered 2,591 (Bechuanaland 1936, *D.R.*).

In *Swaziland* little medical work was done before the Nazarine Mission opened the Raleigh Fitkin Memorial Hospital at Bremersdorp in 1926. In the same year the Wesleyan Mission opened a smaller hospital at Mahamba. This was followed by a small government hospital at Aliatikulu, and in 1931 the small mixed government hospital at M'Babane was replaced by a new one, with three European and twenty-eight native beds (Swaziland 1932). In the view of Sir Alan Pim these facilities were ade-

quate for Europeans, but comparatively poor for the natives, especially in the rural areas where only a few small dispensaries were functioning. He suggested that the utmost use of the assistance of the missions should be made in advancing hospital facilities, whilst the administration should concentrate on extending the system of outstations with trained native nurses, and that small medical outposts manned by trained native orderlies should be established in the large areas which were without any medical facilities.

In 1936 the government European staff consisted of three medical officers, and one subsidized doctor, three hospital assistants, and six nurses. The native staff included 20 nurses (9 men and 11 women). The government hospital at Aliatikulu had been extended to accommodate 48 beds, so that the Southern districts now have a well-equipped hospital. The number of medical outposts had been increased to five, with a sixth in process of construction, and their value was demonstrated during the severe malaria epidemic in the early months of 1937. A special feature of the Bremersdorp Hospital is the training of native nurses for service in the territory, which began in 1935 under the Witwatersrand Chamber of Mines grant for the betterment of medical services for natives in the High Commission Territories (Swaziland 1936, *D.R.*). The latest information gives the total population as 156,715. In-patients were 2,416 and out-patients 30,591. Government medical expenditure amounted to £14,892 out of a total of £131,537.

Southern Rhodesia

In Southern Rhodesia medical and health services are included in the Public Health Department at Salisbury. Private practice is established and the numbers on the registers at the end of 1936 were as follows, though not all of these are resident in Southern Rhodesia: 157 medical practitioners, 44 dental surgeons, 86 chemists and druggists, 219 trained nurses, 36 midwives and 5 mental nurses. Many of these private doctors, of course, aid in the work of the hospitals. The government staff in 1936 consisted of 32 doctors, 2 dentists, a health officer, 2 schools medical officers, 4 medical superintendents, 2 directors of laboratories, a government analyst, 245 general nurses, 20 mental nurses, 87 other European staff and 414 Asiatics and natives. There are eight principal hospitals, with accommodation for Europeans and other

races, at the following centres, in order of size: Salisbury, Bulawayo, Umtali, Gwelo, Gatooma, Fort Victoria, Sinoia, Enkeldoorn, Shamva, and Gwanda. The health of natives is further provided for by six small hospitals erected recently, and two large government institutions for the accommodation and treatment of lepers. The larger mining companies maintain special hospitals for their employees.

It was pointed out in a recent report (Southern Rhodesia 1934, *D.R.*), that 800,000 of the estimated native population of 1,154,500 live in reserves or on unalienated crown land within reach of only a limited number of medical missions subsidized by the government. In the last few years a network of medical dispensaries has been set up throughout native reserves. The aim is eventually to have a series of central hospitals each surrounded by a ring of about eight dispensaries situated at distances varying from 20 to 140 miles from the base. These dispensaries are staffed by trained native orderlies and, wherever possible, are under the supervision of the mission stations operating in the reserve concerned. The government medical officer is in charge and visits all the dispensaries in his area at regular intervals, if possible once a week. In 1936, government issued authority for carrying out a system of native clinics with all possible speed, so that, by the end of the year, in addition to the efficient native sections attached to the government European hospitals, some thirty clinics were either functioning or in process of erection, and it was hoped that a further six would be operating by the following year, and in 1936 22,704 out-patients were treated and 11,744 admitted to hospital (Southern Rhodesia 1936, *D.R.*).

Routine laboratory services are provided and are extensively used by the government service and by private practitioners. The department's laboratory at Salisbury is the chief centre of research and among other studies, work on the anæmias, as they exhibit themselves in the European and in the native inhabitants of the country, has been carried out recently.

The Bulawayo Bacteriological Institute was established in 1930, mainly for routine examinations, and, though partly a private undertaking, was subsidized by the government, railways, and the municipality. In 1936, however, it became an entirely government

institution with the name of the Public Health Laboratory, Bulawayo, and it is expected that the scope of its work will be increased (Southern Rhodesia 1936, *D.R.*).

In 1937 government hospital accommodation was 580 beds for Europeans and 1,111 for non-Europeans and there were 8,040 European and 13,704 Asiatic and African in-patients, while out-patients were 22,685 European and 44,521 Asiatic and African. There were 44 European medical officers and 271 nurses, and 506 African assistants. Government medical expenditure was £252,573 and total expenditure £3,456,704. The population was given as 57,080 Europeans and 1,305,635 natives.

Colonies, Protectorates, and Mandates

Each of the British dependencies has its own Government Medical Department, and the great advances which have been made recently in the control of disease bear witness to the far-sightedness and organizing capacity of the directors and other officers in charge.

For the East African group of dependencies, the Conference of East African Governors has assisted greatly in maintaining touch between workers, in medical as in other subjects. Conferences on the co-ordination of general medical research were held at Entebbe in November 1933 and at Nairobi in January 1936 (Conference, East Africa, 1934a and 1936a), and two on tsetse flies and trypanosomiasis at Entebbe in 1933 and 1936 (Conference, East Africa, 1934b and 1936b). In West Africa such colonial conferences have not yet become a regular feature of medical activity. One such conference, on yellow fever was held at Dakar in 1928 (Selwyn-Clarke 1929) and attended by representatives from both French and British West African colonies.

In addition to these governmental conferences, the part played by local branches of the British Medical Association, especially in East Africa, is considerable. Conferences were held at Nairobi in 1932, at Dar-es-Salaam in 1934, and at Kampala in 1936, and addresses by prominent medical men are arranged frequently. The Association has also inaugurated special research studies, such as an investigation into ulcers in Tanganyika, carried out in 1933.

Most territories have laboratories, each with a staff of patho-

logists or other specialists who are sometimes able to undertake original research in addition to the routine work passed on to them by the hospitals. The principal centres are at Nairobi, Kampala, Dar-es-Salaam, Lagos, Accra, Freetown, and, until recently, the Human Trypanosomiasis Institute at Entebbe, now the Yellow Fever Research Institute. A great difficulty of scientific work in colonial conditions, mentioned often in this volume, is the dissemination of new knowledge to those to whom it would be valuable. The Bureau of Hygiene and Tropical Diseases receives some 500 journals, and publishes in the Tropical Diseases Bulletin abstracts of all articles of interest to Empire workers, and is the principal source of information. An East African and a West African Medical Journal are also published locally. It has been suggested, however, that the service of information could be improved by the creation of local advisory bureaux, conducted on a small scale. In Kenya an honorary Library Committee has recently been inaugurated under the auspices of the British Medical Association. Voluntary readers study the literature and assist the headquarters library in circulating useful information (East African Medical Journal 1935).

In *Northern Rhodesia* the difficulties of making medical services generally available to the populace are greater than in most territories on account of the large area, as big as France, and the comparatively small population, estimated at a million and a quarter. The lack of roads and other means of communication add to this problem. Accordingly, it is admitted and indeed stressed by the Director of Medical Services (Northern Rhodesia 1936, *D.R.*) that little has been done in regard to the health conditions of natives. The large area for which each medical officer is responsible makes the supervision of the outlying dispensaries, etc. difficult. Of the 93 African medical orderlies, about 70 are employed at stations where a medical officer is placed, and the rest conduct dispensaries, mostly at the stations of district administrative officers. The hospital system includes 7 European hospitals, of which the largest at Lusaka was opened in 1935, 12 native hospitals, and 18 rural dispensaries, some of which rely largely on supervision by the administrative department.

In addition to the Government Service, the Roan Antelope,

Mufulira, and Nkana Copper Mining Companies maintain fully staffed hospitals for European and native employees. Missions support 27 hospitals and dispensaries in the territory, 3 of which in 1936 were controlled by qualified medical practitioners and the rest by trained nurses or other partially trained staff. Government subsidies to missions total about £3,000 annually.

The hospitals provide 132 beds for Europeans (figures for natives are not available) and in 1936 there were 1,691 European and 10,700 African in-patients, and 52,151 African out-patients. The rural dispensaries admitted 1,534 Africans and treated 24,160 out-patients. Government expenditure was £852,417 (total) and £65,091 (medical). The staff includes 20 European medical officers, 39 nurses and 3 sanitary inspectors, also European, and 93 African orderlies and 7 microscopists.

In *Nyasaland*, with its relatively small area and dense population, especially in the southern part, which in 1936 was given as 1,838 Europeans, 1,558 Asiatics, and 1,619,530 Africans, medical services can be more easily organized. The staff, under the direction of Dr. A. D. J. B. Williams is relatively large, and nine Asiatic sub-assistant surgeons supplement the work of the medical officers, of whom there were 16 in 1936. There were 10 sisters, 1 matron, and 2 European sanitary inspectors. The African staff of nearly 300 in 1936 included 16 hospital assistants, 177 dispensers, 19 sanitary inspectors, 40 vaccinators, etc. There are eighteen medical posts which are designed to have a European medical officer in charge, but since the strength in the territory is usually only 14, several have to be filled by sub-assistant surgeons or even by African hospital assistants. There are 2 European hospitals, at Zomba and Blantyre, and 15 native hospitals with 93 rural dispensaries, the distribution of which is shown in a map following the annual report for 1936 (Nyasaland 1936, *D.R.*).

The number of beds available in 1936 was 20 for Europeans, 6 for Asiatics, for whom there is a ward in the Zomba native hospital, and 706 for Africans. Government in-patients were 165 European and 9,757 African and others, out-patients 1,685 European and 435,489 African and others; 301,738 cases were treated at rural dispensaries. Government medical expenditure was £48,181 and the total expenditure of the protectorate £617,573.

In 1931, a considerable grant of £43,079 for public health was made to the territory by the Colonial Development Fund, most of which has been spent on the erection of hospitals. There are still many rural areas, especially in the north, which are out of reach even of the smaller dispensaries. In 1935, an advisory Native Welfare Committee, representing all departments interested, was set up. Its main object is to elaborate a co-ordinated welfare policy, and to see that the sums voted for this purpose are divided between the departments in the manner which will secure the best results. A laboratory at Zomba is in charge of a government pathologist, but routine duties prevent much time being given to pure research. The education department has taken interest in spreading knowledge of hygiene. In particular the Jeanes School has a special course for chiefs which has apparently had considerable influence on the type of house erected and even in the selection of village sites.

In *Tanganyika* the Medical Department, under the direction of Dr. R. R. Scott, is divided into branches. In 1936, the medical branch had 39 medical officers, 2 dentists, a dental mechanic, and a nursing staff of 30. The health branch had 6 health officers, 6 lady health visitors, and 21 sanitary inspectors. The sleeping sickness organization had a sleeping sickness officer and 7 agricultural surveyors. The laboratory service is centred at Dar-es-Salaam, but has a special institute for vaccine lymph at Mpwapwa; its staff in 1936 consisted of a senior pathologist, 2 medical officers (seconded), a government analyst, and a laboratory assistant. In addition to these, three research units are maintained by special grants from the Colonial Development Fund. One is devoted to trypanosomiasis research, with a laboratory at Tinde, staffed by one medical officer and a laboratory assistant; one to malarial survey, with two medical officers, an engineer and three sanitary superintendents, and one to tuberculosis research, with one medical officer. These special units accounted in 1936 for an expenditure of £8,549 over and above the departmental expenditure of £185,735. The large Asiatic staff of 55 assistant and sub-assistant surgeons and 24 compounders is a most important part of the establishment. The African staff, which in 1936 amounted to about 2,000, included 109 dispensers and 140 sanitary inspec-

tors. There are 9 hospitals for Europeans. For natives there were, in 1936, 48 government general hospitals, 2 mental hospitals, 297 tribal dispensaries, and 37 medical department dispensaries. A map showing medical stations is included in the annual reports.

In addition to the government service, medical branches of the several missionary societies maintain eighteen hospitals, with a staff of about 18 qualified doctors, who spend nearly all their time on native work.

In 1936 government hospitals had 73 beds for Europeans, 118 for Asiatics and 2,012 for Africans; European in-patients numbered 1,609, and Asiatic and African 36,412; European out-patients were 3,108 and Asiatic and African 594,908. The tribal dispensaries treated 529,954 cases. The population was stated to be: Europeans 8,228, Asiatic 32,792, natives 5,022,640.

In *Kenya* the Medical Department, under the direction of Dr. A. R. Paterson, is arranged in administrative, medical, sanitary, and laboratory divisions. There are proportionately more European medical officers, nurses, and health visitors, but fewer qualified Asiatics, than in Tanganyika. The Medical Research Laboratory at Nairobi was completed in 1931 and is one of the foremost centres in the colonial dependencies. It does all the routine work for Kenya and also serves the neighbouring colonies. The staff consists of 3 pathologists, 2 entomologists, and a biochemist. Much research has been directed to entomological problems (*see* Chapter X) and interesting results have been obtained from investigations of the physiology, brain-structure, mental conditions, and blood morphology and chemistry of Africans (*see* Chapter XVII). The hospital system makes provision for Europeans by three principal hospitals at Nairobi, Mombasa, and Kisumu, and one or two smaller hospitals in townships, as well as a number of private nursing homes. For Asiatics and Africans there are 6 hospitals in the towns, some 23 in native reserves and 6 small hospitals in the northern parts of the colony, including Turkana, the northern frontier province, and Lamu.

In the department's activities, questions of general welfare have received considerable attention, and strenuous efforts have been made to improve the native housing and village sanitation. Much importance is attached to the provision of sanitary inspectors, who

are actually general advisers on native betterment under the medical officers. Health work in the provinces centres, as usual, on the district hospitals, and the aim of the department is to establish a 'health centre' in each large native district, with a hospital and out-dispensaries, the staff to include a medical officer and European nursing sister, and a European sanitary inspector (Kenya 1936, *D.R.*). Some out-dispensaries, staffed by native dressers, are established in the native reserves, seven being maintained by the native administrations.

Maternity and child welfare work has made progress in recent years, and is undertaken by the missionary societies, the municipal council of Nairobi and the Lady Grigg Welfare League, in addition to the medical department.

In 1936 the population was given as 18,269 Europeans, 52,277 Asiatics, and 3,186,976 Africans. Government hospitals provided 73 beds for Europeans, 52 for Asiatics, and 1,928 for Africans. European in-patients were 1,817, Asiatic and African 46,632; European out-patients were 3,609, Asiatic and African 408,788; out-dispensary first attendances were 640,261. In 1936 there were 54 European medical officers (including the Laboratory Division and 2 assistant surgeons), 50 European nurses, 12 sanitary inspectors, and 3 health visitors; among the Asiatic staff were 2 assistant and 24 sub-assistant surgeons; the African staff of 1,204 included 30 health workers, 33 hospital and 92 laboratory assistants, 12 compounders and 648 dressers. Departmental expenditure was £197,049 out of a total of £3,350,381.

In *Uganda* the Medical Department, under Dr. W. H. Kauntze, is sub-divided into administrative, executive, and laboratory divisions. The executive European staff is in general similar to that of Tanganyika and Kenya, but the policy is to insist that the medical officer of the district is responsible for both curative and preventive work. In proportion as qualified African assistants are available, the European medical officer is able to devote more and more time to preventive duties. Among the African staff are 30 medical assistants, holding appointments in the African Civil Service, who have been trained at the Mulago Medical School (*see* later). In many places they have replaced Asiatic sub-assistant surgeons, and some are even in charge of districts. The medical laboratory is situated in the grounds of the Mulago Hospital near

Kampala, and has a staff of 3 pathologists, 1 chemist, and 3 European assistants. A medical entomologist is attached to the agricultural laboratory. Nearly all the work of the laboratory division consists of routine duties. Important research has come, however, from the Human Trypanosomiasis Institute at Entebbe, under Dr. Duke, which was closed down on his advice when he retired in 1935. The hospital system includes a mental hospital, 4 general hospitals for Europeans, 9 for Asiatics, 36 for Africans, and 80 dispensaries without in-patient accommodation. In several districts itinerant medical orderlies hold out-patient clinics at fixed places once a week. A large part of medical effort is devoted to work in rural areas; this has included the improvement of housing and sanitation and the protection of water-supplies. The dispensary system is described later. Among medical missions, the C.M.S., with headquarters at the Mengo Hospital (*see* page 470), has done particularly important work. Courses are provided at Mengo in which African men are trained as doctors, nurses and sanitary inspectors, and girls as nurses and midwives.

In 1937 government hospitals provided 34 beds for Europeans, 56 for Asiatics, and 1,273 for Africans; European in-patients were 517, Asiatic 1,345, and African 29,215; European out-patients were 3,076, Asiatic 7,566, and African 368,151. The European staff included 45 medical officers, 35 nurses, and 17 sanitary inspectors; there were 12 Asiatic sub-assistant surgeons, and several nurses; the African staff included, in addition to 30 trained assistants, 34 health visitors and a varying number of orderlies, midwives, dispensers, nurses, clerks, etc.

Medical department expenditure, in the Estimates for 1938, appeared as £190,121, against a total estimated expenditure of £2,179,659. In 1937 the population was returned as 3,626,549 Africans (estimated), 2,000 Europeans, and 5,000 Asiatics.

The Medical and Health Organization in *Nigeria* and the *British Cameroons*, under Dr. R. Briercliffe, is divided into medical, health, laboratory, and sleeping sickness services. In the medical service the European staff includes the deputy and assistant directors, 85 qualified medical men, 2 lady doctors, 2 dentists, 4 radiographers, and a nursing staff of 62. The African medical staff has 12 medical officers, qualified in Europe and holding appointments similar to those of Europeans. In addition there are now medical

assistants in training, in Lagos, where a course was established recently. The other subordinate African staff of nearly 700 includes dispensers, nurses, midwives, etc. In the health service there are 15 qualified medical officers of health, etc., and 37 European sanitary superintendents. The African subordinates include 196 sanitary inspectors and vaccinators. The laboratory service, under Dr. E. C. Smith, is centred at the African Hospital, Lagos, and the Research Laboratories at Yaba, including the former Rockefeller Yellow Fever Laboratory. There are subsidiary centres at several of the principal hospitals. The European staff consists of 6 pathologists and 7 technical assistants, and there are about 23 African laboratory attendants. The sleeping sickness service has, besides the director, 9 medical officers, an entomologist, and an African subordinate staff of some 14 dispensers, nurses, and attendants.

There are 12 European hospitals, the largest being at Lagos. The African hospitals in 1936 numbered 24 in the Northern Provinces, of which 13 were under native administrations, and 33 in the Southern Provinces, of which 6 are wholly and three partly under the native administrations. In addition there is an extensive system of native administration dispensaries, of which some 300 were established by 1936, 121 in the Northern and 179 in the Southern Provinces. The distribution of all these stations is shown in a map (Nigeria 1936, *D.R.*). The sleeping sickness service, recently inaugurated in the Northern Provinces, has a system of inspection and treatment similar to that in French West Africa and the Cameroons (*see* later). The inspection service examines as large a proportion of the population as possible, though, up to 1937, entirely on a voluntary basis, and the treatment units which follow set up temporary field dispensaries at which inoculations are given. A big step forward in the control of sleeping sickness was made in January 1937 by the enactment of the Nigerian Sleeping Sickness Ordinance (No. 1 of 1937). This applies to the Northern Provinces, including those parts of the Cameroons administered with them, and makes provision for the compulsory examination and treatment of persons infected by the disease, and the proclamation of sleeping sickness areas from time to time. In these areas special measures must be taken by the occupiers of land, and the movement of cattle, people, etc., is under definite control.

Many of the religious missions, which are particularly active in the Southern Provinces, have important medical centres. In 1936 they controlled 22 hospitals, 97 dispensaries, 16 leper settlements, and 116 maternity and infant welfare centres, and treated some 216,500 cases.

The total population was estimated as 20,224,367. The government hospitals provide 148 beds for Europeans and 3,503 for Asiatics and Africans; in-patients numbered 1,116 European, and 60,098 Asiatic and African; out-patients 7,176 European and 650,209 Asiatic and African.

Departmental expenditure was £387,600 out of a total government expenditure of £6,061,348.

In the *Gold Coast* and the adjoining mandated area of *Togoland* the Medical Department, centred at Accra, under the direction of Dr. D. Duff, has medical, health, and laboratory branches. The European staff is relatively large, but most of it is concentrated in the Colony and Ashanti. In the medical branch there were, in 1936, 4 qualified doctors, a dental surgeon, 2 radiographers, and a woman medical officer. There are also 8 African medical officers and a dentist on the senior staff. The health branch has 11 medical officers. The laboratory branch has a centre at Accra and a staff of 3 pathologists and 2 assistants. Routine duties in connection with hospital work absorb practically all their time.

European hospitals numbered 6, of which 4 are situated in the coastal towns and the other 2 are at Kumasi and Tamale. There is also an infectious diseases hospital at Accra. Among African hospitals, the Gold Coast Hospital is the foremost; it is palatially housed, and has a permanent staff of 5 medical officers, radiographers, etc. It is a training centre for nurses, dispensers, and other subordinates, and to it are sent all cases requiring special diagnostic methods or treatment from the other hospitals in the colony. There are in all 32 African general hospitals, each in charge of a medical officer, 9 hospitals for contagious diseases, 16 village dispensaries, and 2 field hospitals in the extreme north of the territory, dealing mainly with sleeping sickness. There are also child welfare centres, of which three are financed by the Gold Coast branch of the Red Cross. The distribution of these centres is given in a map (Gold Coast 1936, *D.R.*).

It is fair to state, regarding the departmental activities as a whole, that there has been a pronounced concentration in the Gold Coast on the hospital system, and many buildings have been erected in the important towns at great expense. The numbers above show, however, that the system of dispensaries in rural areas has not yet been fully developed. It appears that initiative here is left largely to the African chiefs, and dispensaries are usually erected only by special request. It is true that transport systems in the colony and Ashanti are so well-developed that many patients in rural areas can reach the hospitals for consultation and treatment, but provision of this kind can hardly be expected to reach the bulk of the population.

In 1937 the population was estimated at 3,703,517. In 1936 government hospitals had 68 beds for Europeans, 995 for Africans in the general hospitals and 121 in the contagious diseases hospitals. In the same year European in-patients numbered 931 and African 26,150; out-patients (European) were 2,095 and (African) 282,035.

Government medical expenditure in 1936 was £312,413 (recurrent) and total expenditure £2,337,357 (recurrent).

In *Sierra Leone* the Medical Department, which is under the direction of Mr. P. D. Oakley, has separate medical and health branches. In addition to the European staff of 15 qualified medical officers, etc., there are 7 qualified African doctors, including a senior medical officer and a pathologist. There is a central European hospital at Freetown. Of hospitals for Africans, the Connaught Hospital at Freetown is by far the largest and dealt with 2,549 in-patients and 18,193 out-patients in 1936. There are 4 other African hospitals at Makeni, Bo, Moyamba, and Port Loko, the last erected during 1936, a fifth was to be erected in 1937. Three mission hospitals in the Protectorate and one in the Colony are subsidized by government, and a dispensary system has 8 centres in the Colony and 14 in the Protectorate. Each of these is in charge of a senior dispenser and is inspected frequently by the district medical officers. As in the Gold Coast there has been a concentration of medical work in the capital, and the Colony surrounding it.

In 1935–6 the population was estimated at about 2,000,000 Africans and Asiatics, and 700 Europeans. In 1936 government hospitals pro-

Above: THE GOLD COAST HOSPITAL, ACCRA
One of the most completely equipped medical centres in tropical Africa

Below: ASHANTI MOTHERS AND CHILDREN
The child most recently born receives most food and attention
(Photograph by Dr. Cicely Williams)

vided 14 beds for Europeans, and 535 for Africans. There were 180 European and 5,270 African in-patients, and 474 European and 110,524 African out-patients. In addition to the staff already mentioned there were 7 European nurses and 3 sanitary superintendents, the African subordinate staff of about 160 included 39 dispensers, 3 health visitors, 42 sanitary inspectors of different grades, nurses, and midwives.

Estimated government medical expenditure for 1936 was £66,894.

The medical department of the *Gambia* is in charge of the Senior Medical Officer, Dr. A. M. W. Rae, and the staff is concentrated in Bathurst, there being few medical facilities elsewhere. Of the African staff totalling about 40, only 11 are posted outside Bathurst. The Victoria Hospital is the centre of the service, and is probably the only large hospital in Africa in which patients of all races are housed under one roof. The only hospitals in the Protectorate are at Georgetown and Bwiani. There are dispensaries at other centres, including one organized voluntarily by the wife of one of the administrative commissioners, Mrs. R. W. Macklin. A maternity and child welfare clinic has recently been established in Bathurst.

A special problem, to which much attention has been drawn in recent years, is the sanitary condition of Bathurst. Plans have been prepared with the object of raising the level of much of the town, which at present is scarcely above sea-level and is extensively submerged during the rainy season. As Dr. Rae points out in his report for 1935, the greater part of the cost of curative treatment must be wasted if the patients are to return to living conditions in which a recurrence of their malady is almost certain to take place. An outline of the proposals was published by Professor Warrington Yorke (1937), but the financial position of the colony has not been held to warrant special expenditure on this work from the Colonial Development Fund or other sources. The year 1936 showed a considerable development in the work of the medical department. A hospital at Bwiani, chosen on account of the prevalence of sleeping sickness in that area, and a dispensary at Kaiaf were opened, funds for both having been provided by the Provincial Emergency and Development Fund. Kaiaf dispensary had over 3,000 cases in its first seven months, and Bwiani had 7,000 cases and 94 in-patients. A child welfare centre at Sukuta was

also started in a building loaned by the Methodist Mission, and a leper camp was started by a progressive chief at Buruko in MacCarthy Island Province. During 1936 also the holder of a senior research scholarship in tropical medicine from the Medical Research Council was working in the colony. (Gambia 1936, *D.R.*)

In 1937 there were 3 government hospitals, the Victoria, Georgetown, and Bwiani, providing 9 beds for Europeans, and 98 for Asiatics and Africans; in-patients numbered 49 Europeans, 25 Asiatics, and 1,619 Africans; out-patients 115 Europeans, 61 Asiatics, and 31,576 Africans. The European staff included 6 medical officers, 4 nurses, and 2 sanitary inspectors; there were 2 African assistants and about 40 other employees.

Government medical expenditure was £32,110 out of a total of £343,323. In 1935–6 the population was reported to be nearly 200,000 Africans and others, and just over 200 Europeans.

FRENCH

A full account of the public health services in the French colonies as they were ten years ago, was published in English by the League of Nations Health Organization (Abbatucci 1926), and also in the statements prepared for the International Colonial Exhibition of 1931 (A.O.F. 1931). Medical policy has not changed materially since then, but the following account, based on more recent data, is given for purposes of comparison with the organization in British and Belgian colonies.

There is no central institute for research and training in France quite comparable with the London School of Hygiene and Tropical Medicine, but the *Pasteur Institute* in Paris serves similar functions as a centre to which governments may refer for advice, whilst the prestige of the institute has proved a great inducement to research work in the colonies. In the French dependencies the institute has branches which receive direction from Paris, but are partly supported by the local governments (*see* later). The *Ministry for the Colonies* in Paris is the headquarters of the general Inspectorate of all the colonial health services.

Each of the colonies of the West African Federation, the city of Dakar being regarded as a distinct unit for this purpose, has a *Chef du Service de Santé*, directly responsible to the Governor, and so to the Governor-General. These *Chefs du Service de Santé*, however,

also report to the Inspector-General of the Health Services centred at Dakar, who, with his staff of inspectors, is responsible to the Inspectorate at the Ministry for Colonies in Paris, and advises the Governor-General at Dakar.

In each colony the *Chef du Service de Santé* has under him a staff of European doctors, of whom the majority are military, having received training in tropical diseases at the *École d'Application* at Marseilles. In addition the trained African auxiliary staff includes 'auxiliary' doctors, midwives, and health visitors who have passed through the medical school at Dakar. The medical staff in French West Africa includes 180 European medical officers, 68 European nurses and dispensers, and 30 health visitors; there are 185 African 'auxiliary' doctors, 250 health visitors, and 1,733 subordinates.

In the past there has been difficulty in obtaining French civil doctors, and many foreigners have been engaged as assistants. This difficulty still exists in some degree, especially in Equatorial Africa, so that some military doctors are seconded to the civil branch. All the subordinate staff are trained in the colony where they serve.

Each colony has its principal hospitals, of which those at Dakar, St. Louis in Senegal, Bamako in the Sudan and Abidjan in the Ivory Coast are regarded as first class. That at Dakar consists of a large building for Europeans, another for Africans with 432 beds, which is used principally for surgical cases and does not deal with epidemic diseases (*see* later), and a maternity building for Africans, which deals with some 800 deliveries per year. The hospital at Bamako, on the other hand, appears to be mainly for Europeans and has a large staff in proportion to the patients; it is separate from the dispensary service, which provides mainly for Africans. Hospitals of the second category are at Conakry in Guinea, Porto Novo and Cotonou in Dahomey, and the third-class hospitals, each with a surgeon and radiographer in addition to clinicians, are at Bobodioulasso and Ouagadougou in the northern part of the Ivory Coast, and at Niamey in the Niger Colony.

These hospitals naturally absorb a part of the staff mentioned above, and the rest is now, or will be, distributed according to a definite scheme as follows: every *Cercle* or province has one or sometimes two medical centres which correspond to the provincial

hospitals of a British colony, each with a European doctor in charge and some with an African auxiliary doctor as well. Here urgent surgical cases are dealt with, but the chief object of these medical centres is to supervise a ring of subsidiary centres (*infirmeries*) in charge of native auxiliary doctors, each of which, in turn, is surrounded by dispensaries in charge of *infirmiers* or nurses. There are usually two or three medical posts with auxiliary doctors in each *cercle*, but in some parts of Guinea and the Ivory Coast there are up to nine in a *cercle*. In theory the doctor in charge of the *cercle* visits each of his out-stations once a week. This system is nearly complete for Dahomey and the lower regions of Senegal, and is being extended as native auxiliary doctors and other staff are being produced at Dakar, but there are large areas still without dispensaries. The French insist on keeping all African staff under close supervision, and hence do not open more dispensaries than can be visited by European staff at frequent intervals. This attitude may be contrasted with that in the British colonies for example, where, though the African staff is usually less highly trained, its members are often entrusted with more responsibility.

Another important difference between the French organization and some British systems is that the hospitals are regarded essentially as the headquarters for a large number of field stations in rural areas, rather than as centres to which sick people should come for expert treatment. In appearance, these medical centres present a striking contrast to British provincial hospitals. At first sight there appears to be a lack of order and cleanliness. The families of patients live in the hospital compound and produce all the patient's food themselves. The wards are long low buildings, divided off into separate chambers, in each of which there may be several sick people lying on mats and covered only by blankets, living with their wives and children. Well over 100 in-patients are so disposed. Out-patients to the number of 350 or more in a day are examined by the military doctor and his native auxiliary. Such conditions might drive the staff of a British hospital to resignation, but the enormous number of patients indicates the popularity of the French system. This type of medical attention, though greater in quantity, is probably inferior in quality compared with the British. The latter system may be described as seeking to per-

suade the native to appreciate the high standards of European medicine; the former as lowering the standard to meet the current native ideas.

In addition to the native hospital, Dakar itself has a unique medical centre, the *Policlinique*, which is run in conjunction with the medical school. This serves as an out-patient centre for the whole African population, but its principal object is held to be the training of native auxiliary doctors, midwives, and dispensers for work in the rural areas throughout the Federation. In the large building with its highly developed statistical and recording organization, some 380,000 consultations, representing about 63,000 cases (i.e. more than a thousand consultations per day), take place annually. The staff consists of five French doctors, some of whom are specialists resident in Dakar who spend some hours each day at the clinic, a French trained midwife and three French nurses, an African auxiliary doctor and a large number of medical students, including about fifty prospective doctors and twenty midwives. There are separate departments for infant welfare, maternity, ear and eye treatment, and a small laboratory is attached. Radiology is likewise provided for, and every schoolchild in Dakar receives full medical examination there twice a year.

For sanitary work the French rely on the ordinary medical staff, except at Dakar and one or two other large centres, where special *gendarmes* see that medical orders about mosquitoes are carried out, and a separate sanitary service for the destruction of rats, etc. is in operation.

In addition to the systems outlined above, there are special organizations to deal with certain native diseases such as sleeping sickness. These, known as *équipes de prospection et traitement*, numbered in 1936 ten in the northern part of the Ivory Coast, two on the western border of that colony, three in Dahomey, one in Niger colony, two in the Sudan, one in Senegal, and two in Guinea, making a total of twenty-one, and twelve others were in formation. Each *équipe* consists of a European doctor, accompanied by one or two native auxiliary doctors and some two dozen *infirmiers*, of which three-quarters are trained in microscopic work to identify the trypanosomes or other blood parasites. The *équipe* is divided into two parts, the first, consisting of the doctor in charge and the

microscopists, arrives in a village and examines every individual. Other diseases as well as sleeping sickness are noted on each person's card. The second section, in charge of the native auxiliary doctor, follows, and establishes a temporary treatment centre for each group of three or four villages. The auxiliary doctor may establish a dozen or so of these treatment centres and visits them once a week. All patients suffering from sleeping sickness or other curable diseases come to the centres for injections at regular intervals until the disease is stamped out of the neighbourhood. By this means it is proposed to clear up one area after another, and as each is vacated it is left for the ordinary system of medical centres and dispensaries to keep observation on sleeping sickness in case of a further outbreak. The training centre for the native personnel for this special sleeping sickness work is at Ouagadougou, where three Europeans, including a bacteriologist and an entomologist, are permanently resident.

In each colony, moreover, a reserve of personnel, tents, and sanitary material is maintained at the chief medical headquarters to deal with epidemics. The whole forms a complete portable hospital which can be transferred at very short notice to an infected area. This system is used chiefly for epidemics of plague and yellow fever, and has been developed since plague was introduced to Senegal in 1914, and reached its climax with the devastating epidemic of 1927. Since then a great reduction of the disease has been effected through the use of these hospital camps.

For research purposes reliance is placed largely on the *Pasteur Institute*, which has branches at Tunis, Dakar, at Kindia in Guinea, Brazzaville in French Equatorial Africa, and Tananarive in Madagascar. These are widely consulted by the colonial medical organization, and perform many routine functions such as the preparation of vaccine for plague, yellow fever and other diseases. The Institute at Dakar for which a large building was recently completed, is in charge of General Mattisse, and provides all the yellow fever vaccine for the French African colonies, made, according to the Laigret method, from the brains of white mice. In addition, there is a bacteriological laboratory at Bamako in the Sudan, with a staff of a French doctor and five African *infirmiers*, which produces vaccines for rabies, smallpox, and tuberculosis, approximating in

all to nearly one million doses a year. There are other similar laboratories for routine work at St. Louis and elsewhere, under the direct control of the *Chef de Santé.*

Annual medical reports from the individual colonies are not published, but general accounts of recent developments and the results of scientific work by colonial doctors appear frequently in the *Annales de Médecine et de Pharmacie Coloniale*, which is an official publication of the Ministry of Colonies in Paris. Other specialist journals are the *Bulletin de la Société de Pathologie exotique, la Société de Biologie, la Presse Médicale* and *les Annales de l'Institut Pasteur.*

For leprosy a central Institute was established in 1933 a few kilometres from Bamako. It has laboratories endowed for research, and provides accommodation in a special village for all the sufferers in French West Africa. By 1936 there were 325 already living there, mostly from the Sudan and Ivory coast. The staff consists of two doctors, three nursing sisters, *infirmiers*, and African nurses.

Private organizations and missions do not play so important a part in French African medical work as they do in the Belgian Congo, but they have grown considerably in recent years. In all the colonies there are branches of the *Croix-Rouge française* and of the *Berceau Africain*, in direct contact with their headquarters in Paris. These institutions are, for the most part, concerned with infant welfare.

There were in 1937 in French West Africa 11 government hospitals and 437 ambulances and dispensaries; beds available for patients are 788 for Europeans and 5,484 for Africans. In-patients were Europeans 19,859, Africans 3,113,819. Total government expenditure amounted to 615 million francs and expenditure on medical services 38 million francs. The population is estimated at 15,000,000.

French Equatorial Africa has a similar medical organization to French West Africa. The four regions of Gabon, Congo, Oubangui-Chari, and Chad have each a Chef du Service de Santé, and an inspectorate with an Inspecteur-Général in charge is situated at the capital at Brazzaville. The number of staff is not so great as in French West Africa, but the same policy of keeping hospitals mainly for surgical cases and concentrating on outside work is followed. *Equipes de prospection et traitement* for sleeping sickness like-

wise function, though on a smaller scale, and in 1936 dealt with 12,567 new cases; field work of this kind and village treatment is difficult in view of the four months' rainy season. There is a leper village at Fort Lamy, and sleeping sickness villages are established by the *équipe* system for the treatment of serious cases who are compulsorily segregated. Medical missions are also active.

The population in 1936 was about three and a half million. In 1936 there were 5 hospitals, 52 dispensaries, some of which were mobile units, and 46 health centres; 66,736 cases were admitted to hospital and 2,751,103 consultations given. The staff included 80 doctors, 5 chemists, 9 *hygiénistes*, 6 midwives, and 46 European and 644 native (male) nurses. The medical budget was about 20 million francs for 1936.

In the *Cameroons* and *Togoland* the French medical services are more extensive than in French Equatorial or parts of French West Africa, though similarly organized (Cameroons (French) 1936; Togoland (French) 1936). In the Cameroons in 1936 the staff of the official *Service de Santé* included 74 Europeans, of whom 45 were qualified doctors and the rest chemists, dispensers, and sanitary agents. The trained auxiliary African staff, mostly *infirmiers*, numbered 667. Good hospitals are established in each regional headquarters, with *centres médicaux* in the district headquarters, and dispensaries in charge of *infirmiers* in the subdivisions. The numbers in 1936 were as follows: 1 European and 4 native hospitals, 3 *centres médicaux* for Europeans and 18 for natives, and 38 dispensaries, of which 11 are provided with beds. The total number of beds at these institutions is 54 for Europeans and 2,064 for natives. Maternity and child welfare has been a special feature of the work; in 1936 there were 15 maternity centres and 19 dispensaries for infant welfare, with a total together of 792 beds. In addition, in 1936, there were special establishments under the department including 26 leper colonies, 13 centres for contagious diseases, and 10 sleeping sickness centres.

Sleeping sickness, which is regarded as the most important disease in the territory, is dealt with by *équipes de prospection*, similar to those described for French West Africa. In 1936 there were six *équipes* permanently at work followed by 12 detachments for treatment. The staff of these is additional to the figures given above.

By a compulsory system of attendance and full recording systems, a medical census has been made in much of the area. Furthermore, the movements of natives in all sleeping sickness districts are under full control by a system of medical tickets, obtained at hospitals after examination. Without one of these it is impossible for a native to buy a railway ticket or to make use of other regular forms of transport.

Among medical missions the American and French missions figure prominently. Together they have a staff of 11 qualified doctors, 46 European fathers, some of whom hold medical diplomas, and a trained African staff of 174 *infirmiers*. In 1936 the missions maintained 8 hospitals with two more in course of construction; hospital beds numbered 752 and dispensaries 37.

The Laboratory Service is centred at the *Institut d'Hygiène* at Douala, which comprises laboratories for bacteriology, serum work, entomology, parasitology and chemistry.

In 1936 hospital in-patients numbered 220 Europeans and 15,728 Africans; out-patients 3,834 Europeans and 453,270 Africans; the dispensaries treated 356,276 Africans, the *centres médicaux* 9,601 in-patients and 134,316 out-patients, and the mobile units a total of 596,555. At the end of 1936 the European population was returned as 2,324 and the native as 2,377,125. In 1935 the total ordinary expenditure was 57,798,926 francs, and that of the Service de Santé, 8,978,269 francs.

In *Togoland* the medical staff in 1936 included 13 Europeans, 10 being qualified doctors. The African staff included 6 auxiliary doctors trained at Dakar, 12 midwives, and 185 other assistants such as *aides médecins*, *infirmiers*, etc. There is one central European hospital, at Lomé, with 10 beds, and there are 9 African hospitals with 318 beds, 5 *centres médicaux*, 21 dispensaries, of which 7 have some 25 beds each for African patients, and 5 maternity centres. Sleeping sickness was dealt with in 1936, as usual, by one *équipe de prospection*, followed by 7 treatment detachments, which dealt with over 15,000 new cases. A special sanitary service has been established in Lomé to reduce the incidence of plague by a campaign against rats, of rabies by destroying stray dogs, and of malaria and yellow fever by mosquito control measures. A laboratory attached to the Lomé hospital is entirely for routine

purposes. The chief research carried on is the collection of demographic data by the *équipe de prospection.*

In 1936 the population was reported as 735,606 Africans, 50 mixed races and 400 Europeans. In 1936 there were 62 European and 4,255 African in-patients, and 933 European and 544,515 African out-patients.

Government expenditure in 1935 amounted to 25,748,748 francs, and that of the *services sanitaires* 3,863,897 francs.

BELGIAN

The *Institute of Tropical Medicine at Antwerp*, under the directorship of Professor J. Rodhain, corresponds to the London School of Hygiene and Tropical Medicine as a headquarters. Collaboration exists between this institute and the state laboratories in the Congo, so that many of the problems which occur in Africa are referred to the institute, and most of the results of research appear in the *Annales de la Société Belge de Médecine Tropicale*, published since 1920.

Of the services working in the Congo there is first the *State Medical Service*, which has a headquarters in Brussels at the Ministry for Colonies under Dr. A. N. Duren. This has charge of health in the whole colony. Under the state service the railway provides a special medical organization for its employees. In Katanga the medical service is also dependent on the central state service, and receives assistance from the railway and industrial medical services; it publishes the *Bulletin Médical du Katanga*, which gives a full account of the work at the hospitals, clinics and research centres in Katanga. On the research side there is a state laboratory at Leopoldville, with a large research staff, and others at Coquilhatville, Stanleyville, Elisabethville and Katega, each with one research officer. The European staff of the service included in 1937 74 doctors, 6 *médecins hygiènistes*, 243 nurses and 16 health visitors, while there were 1,920 Africans such as nurses, *aides-infirmiers*, medical assistants, and 31 *gardes sanitaires*. The mandated territory of Ruanda-Urundi had 15 doctors, 1 dispenser, and 12 sanitary agents, and the native staff of 295 included 12 medical assistants, 12 qualified nurses, 105 *aides-infirmiers*, and sanitary workers.

Although the government service is responsible for medical

work in every district, there has been a greater development of unofficial organizations than in the British or French colonies, a situation comparable with that in Belgium, where preventive services are largely in the hands of voluntary associations. These work in well-defined areas under Government control, which exists by legal agreements in the case of mining companies, by reason of conventions or in return for subsidies in the case of benevolent societies and missions.

Belgian policy has concentrated to a marked degree on the extension of facilities to rural districts. For medical purposes each administrative district is sub-divided into a number of territories. These are allotted to the official organizations known as the *Service de l'Assistance Médicale aux Indigènes* (SAMI), and the unofficial bodies known as the *Service Auxiliaire de l'Assistance Médicale aux Indigènes* (SADAMI). The SAMI includes the state service mentioned above, and a subsidiary organization especially endowed, the *Fondation Reine Elisabeth pour l'Assistance Médicale aux Indigènes* (FOREAMI); while the SADAMI includes the numerous medical missions and religious infirmaries, which are doing remarkably fine work, and also two important organizations —the *Croix-Rouge du Congo* and the *Fondation Médicale de l'Université de Louvain au Congo* (FOMULAC).

The FOREAMI, established in 1930, has large financial resources and has done remarkable work. A capital sum of 150,000,000 francs was provided as a permanent endowment, 100,000,000 from the Congo Government, 50,000,000 from the Belgian Government, and an additional gift of 288,853 from Queen Elisabeth. The annual expenditure has risen from 2¼ million francs in 1931 to nearly 11 million in 1934. Dr. Trolli, formerly Chief Medical Officer of the Congo Free State Service, is director of the organization, and some 27 Belgian doctors and 20 sanitary agents, together with a large number of African assistants are maintained permanently in the field. The FOREAMI has complete charge of the medical work in a huge, but well-defined zone, in which a more thorough medical service for the natives than that in the rest of the colony has been organized. The FOREAMI subsidizes the private medical organizations in its area, especially the missions, which collaborate in its policy. The method adopted,

is to concentrate on one area for a few years, to eradicate as far as possible preventable disease, build hospitals, dispensaries, doctors' houses and roads, and then to hand the cleaned area over to the state service, which should be able to maintain the work with a comparatively small staff. Meanwhile the FOREAMI moves on to the next sector to continue the process.

Since the organization came into existence its principal area of activity has been in the Bas Congo among the Bakongo tribe. The centre of attack is now being moved to the adjoining sector of Kwango, and the work of building roads, houses, and dispensaries in the new area is already well advanced. The demographic work done in the Bas Congo is considered later. There is a secondary centre for sleeping sickness work in the Ruzizi-Tanganyika region, where this disease is rife (FOREAMI 1931–5).

Passing to the SADAMI services, among the mission centres those belonging to the Roman Catholic faith are the most numerous and receive considerable government grants. Doctors belonging to the *Missions Nationales* numbered 12. Protestant missions have a considerable organization in the Lower Congo, on the Upper Congo River and in Kasai. A number of denominations are represented; altogether they maintained, in 1934, 29 European doctors with a number of hospitals and dispensaries.

The *Croix-Rouge du Congo*, with Madame Dardenne as director, started in 1925 and was the first unofficial medical organization in Africa apart from missions. It has been the aim throughout to achieve results in a limited area rather than to diffuse activities to an extent which would be too large to maintain, if at any time funds were curtailed. Accordingly the main work has been concentrated on a small area in the Uélé region, where a staff of four doctors and eight sanitary agents is established. The three principal objects which have been accomplished are the establishment of rural dispensaries, maternity work, and the construction of a leper village, where the inhabitants make their own houses, grow their own crops and are practically self-supporting.

The *Croix-Rouge* has established a few other centres organized by local committees. At Leopoldville, where the native town has a population of 25,000 men and 10,000 women, venereal disease clinics have been opened; at Coquilhatville a maternity centre

has been started, and village dispensaries are being established in the neighbourhood of Elisabethville. No fees are charged and natives flock to the dispensaries and clinics. Short reports are published annually in Brussels.

The FOMULAC, like the CADULAC, which is concerned with native agricultural improvement, originated from the colonial enthusiasm of the University of Louvain. Its objects and methods of bringing medical assistance direct to native villages are similar to those of the *Croix-Rouge*. Two important centres have been established at Kisantu and Katana, and a smaller post at Yasa. Four doctors are maintained in Africa by the organization and short reports are published annually in Louvain.

The mining and other companies, of which the principal are the *Union Minière du Haut-Katanga*, the *Société des Mines d'Or de Kilo-moto*, the *Forminière* and the *Huileries du Congo Belge*, all have efficient medical services with the object of maintaining health among the employees. In all some fifty doctors are supported in Africa by the companies. All concessions carry the condition that hospitals and schools must be provided for the natives, but several of the companies have done far more in these directions than they were bound to do. Since the importance, even from an economic point of view, of improving the standard of living and the general hygiene among the families of their employees is fully realized, the influence of these services has extended considerably beyond the immediate vicinity of the industrial centre. For example the *Huileries du Congo Belge* support maternity hospitals and training schools for native midwives. The free treatment given at general hospitals and dispensaries is not restricted to the company's own employees and their families. Five boarding schools to take 1,500 children have been established, where everything, including food and clothing, is provided free. A separate brick house and a garden is given to each married employee, and by 1931 some 8,000 houses had been erected. There is a natives' savings bank which pays 5 per cent on deposits, and a sum for the bride-price is advanced to employees wishing to take wives. Extra accommodation is provided for families with children, and a blanket is given for every child born. The upkeep of these social services costs the

company some £50,000 annually, and up to 1931 £165,000 had been expended on buildings.

The activities of the other large companies are proportionate; thus the *Union Minière* has a maternity centre and feeding consultant at each of its branches; consultations and free meals are provided for children up to five years, and subsequently schools with free meals up to fifteen years. This organization is specially developed in Jadotville, where it is assisted by two mission medical centres (van Nitsen 1933). The *Société de Kilo-moto* has two maternity homes, two orphanages and several schools, and gives about 95,000 free consultations on diet every year. The *Forminière* has established the Berceau de Kasai at Tshikapa with the object of reducing infant mortality.

In 1937 the population of the Congo was given as 20,103 Europeans and 11,000,000 Africans. The government maintained 25 hospitals for Europeans, 2 for Asiatics, and 70 for Africans, with bed accommodation of 317 (Europeans), 17 (Asiatics), and 6,420 (Africans); 2,913 European and 85,279 African in-patients were treated and 14,584 European and 836,322 African out-patients. The Missions Etrangères treated 836,322 cases, and the Assistance Médicale Bénévole aux Indigènes 560,896. Le Budget Ordinaire for the Belgian Congo for 1937 was 665,487,207 francs and that of the medical service 62,375,218 francs.

In Ruanda-Urundi in 1936 4 hospitals were maintained, and treated 54 European and 4,720 African in-patients; a further 1,679 were admitted to other medical centres; 665 European patients were treated and a total of 995,894 Africans by Government and subsidized mission services. In 1936 the budget provided for an expenditure of 4,833,825 francs on the *service de l'hygiène* out of a total of 31,279,468 francs.

PORTUGUESE

Little information is available on recent medical developments in Angola and Mozambique. In Portugal the Lisbon School of Tropical Medicine is an important headquarters, and for Mozambique there are central laboratories for medical research at Lourenço Marques, where sleeping sickness is the principal disease studied. In 1934 there were 13 hospitals with 75 doctors and a considerable staff of European and native assistants. Since the First Congress of Tropical Medicine of West Africa at Loanda in

1923 the advance in medical work in Angola has been notable, and a hospital and dispensary system is now established. In 1935 there were 15 hospitals, with 65 doctors and some European assistants. Special courses of training are held for native nurses and other subordinate staff. In Angola the Baptist Missionary Society (London) and several American missions support about eight hospitals, each with a doctor and most with a nurse in addition. The Baptist centre at San Salvador trains native medical assistants and nurses.

PAYMENT FOR MEDICAL SERVICES

Throughout Africa, as in other parts of the world, certain government servants receive free medical attention; non-officials are expected to pay for it when they can afford it, and private practitioners charge fees according to the usual system. The question whether government doctors should be entitled to undertake private practice has accordingly arisen. This is allowed in many areas but it is the policy of the Colonial Office eventually to prohibit it.

Practice as regards charging fees to African patients varies in different territories. In the French colonies payment is asked only in exceptional cases where patients can obviously afford it, although in Togo under French Mandate there is a scale of charges for treatment. It must be remembered, however, that under the French system the food and clothing are not provided for hospital patients. In the Belgian Congo under the State Medical Service free treatment is given except for accidents and most surgical cases, when some payment is expected from patients who can afford it, as a contribution towards the cost of the materials used for their treatment. No fees to doctors are paid by natives. Whereever possible the relatives of hospital patients are expected to contribute food for their support.

In most of the British colonies the majority of natives receive attention free. In some, small charges are made for supplying medicines, etc. This policy has been adopted especially in Uganda, except in the cases of notifiable infectious disease or of indigent persons and expectant mothers who are always treated free, and

some revenue is obtained by this means, particularly for salvarsan injections. For these, payment is charged on three scales in accordance with the average wealth of different areas, and patients are encouraged to take a full course of treatment by a reduction in the fee per injection. In hospitals and dispensaries there is a charge of up to two shillings a week for in-patients in a general ward, subject to ability to pay, and seven shillings a day for a private ward.

In Basutoland the out-patient departments of each of the six hospitals charge one shilling for each attendance from native patients, but in-patients pay nothing.

It has been urged that all medical treatment of Africans should be free, on the grounds that the services are largely financed from native taxation, and that the provision of free treatment might encourage further resort to it. On the other hand many authorities hold the opposite view, that Africans in rural areas are likely to appreciate treatment more if the service is not taken entirely for granted. Experience in many parts of the continent shows that Africans, like Europeans, are apt to think that the benefit they receive from treatment is in direct proportion to the amount they pay. In Kenya Africans have been found to believe that an injection which costs ten shillings is ten times better than one costing one shilling, and practical difficulties ensue, since they will save up for expensive single injections and imagine that they need not take courses. There might seem to be advantages in a simple co-operative system whereby small fees were charged on a regular basis and responsibility for payment rested with the village headmen.

Some authorities regard as preferable the provision of free treatment, a certain proportion of the poll-tax being considered as a contribution on the lines of health insurance in some European countries, the balance of the cost of medical services being met by a grant from the state and a tax on the employer of labour. The definite allocation of a percentage of the poll-tax would tend to stabilize expenditure on medical services even in periods of financial depression, and limit reduction of service to specific benefits rather than allow a general reduction of medical work just at a period when the need for it is greatest. A special aspect of this

problem arises in areas, such as Uganda, where salvarsan has come to be regarded as the cure for all ills. It is unfortunately a frequent practice for certain African medical attendants to make illegal profits by the sale of salvarsan which is either stolen or collected by giving doses less than those ordered. A system of supervision close enough to prevent these defalcations is practicable, but if free treatment were recognized as a right acquired by the payment of poll-tax, the African himself would probably insist on his rights; the danger would then more probably come from demands for salvarsan for every ailment.

The development of health insurance in England based on the part-time employment of private practitioners has not proved satisfactory from every point of view, and the arguments against it apply more forcibly to African conditions. Therefore, the provision of free treatment by a state service might well prove a more satisfactory line of development for Africa.

MEDICAL EDUCATION OF AFRICANS

The improvement and maintenance of health in Africa depends largely on the provision of trained African assistants who can undertake routine work at hospitals, and can take medical aid direct to the rural areas while working under the supervision of European medical officers (*see* Chapter XVII). The training of dispensers, nurses, dressers, and midwives has been established for some years in most African territories, but recently the lack of a more highly trained auxiliary staff capable of efficient diagnosis and treatment has been seriously felt. The medical service, as other services, can be envisaged in the form of a pyramid, in which the base is formed by a large number of nurses, dispensers, etc., the apex by the European medical officers, and the central part by auxiliary doctors or medical aids. This intermediate class exists in East Africa in the form of Asiatic assistant and sub-assistant surgeons and in Uganda of African medical assistants, but in West Africa, although there is beginning to be a supply of African auxiliaries, and African doctors qualified in Europe already fill some senior posts, nearly all the work of routine diagnosis and treatment has to be done by Europeans.

There are thus two aims in medical education in Africa: first to produce auxiliary doctors to form the middle of the pyramid, for which the system of training must be based on that well-proved in European countries; second to produce the dispensers, nurses, dressers, and other subordinates at the base of the pyramid. For the first type it is obvious that special medical schools are essential, but for the second, training facilities can be made available at hospitals, though special schools are of value for the higher grades such as dispensers, midwives, and sanitary inspectors. The training of auxiliary doctors should of course have in view the eventual appointment of the ablest to senior posts. There must, however, be an intermediate stage in which partially, as opposed to completely, trained men serve in positions where considerable supervision by superior officers is exercised. This partial training is often opposed by the medical profession, but it is coming into prominence in several parts of the world. In Central Europe the Felcher System is already under trial: partly trained doctors are returned to peasant villages where they usually marry and sometimes combine a small practice with some other occupation. A similar system is being developed in India, and is contemplated in China and Japan.

The systems of training in Africa have been surveyed by Buell (1928), and more recently Dr. C. C. Chesterman (1932) has outlined the practice of Sierra Leone, the Gold Coast, Nigeria, the Sudan, Uganda, Tanganyika, Nyasaland and the Belgian Congo. He advocates many small schools, since these have the advantage of personal contact between teacher and student. The most recent survey of facilities for medical training in East Africa is given in the report of the Commission on Higher Education in East Africa published in September 1937.

AUXILIARY DOCTORS

The centres where auxiliary doctors are now trained number five; the medical schools at Dakar, which provides *médecins auxiliaires* for all French West Africa, at Yaba near Lagos in Nigeria, the Mulago Medical School at Kampala in Uganda, the Native College at Fort Hare in South Africa and the Kitchener School of

Medicine at Khartoum. The last-named lies outside the scope of the present study.

The training at Dakar was started immediately after the Great War, and may be described first as the earliest established and largest school for auxiliary doctors in Africa. The prospective medical student spends two years on secondary education at the École William Ponty on the Island of Gorée. Then follow four years of intensive training at the Medical School, for which only the better students are chosen. The first two of these years are devoted to a grounding in the usual subjects such as physiology, anatomy, pathology, and hygiene, but during the last two years the students divide their time between the Medical School proper and the Policlinique and African hospitals, where a large part of the routine diagnosis and treatment is carried out by them under European supervision. The actual work is much the same as in a British medical school, but there is no 'long vacation', and the students have more working hours during the four years at Dakar than during the five or six years in a British medical school. There are rather more than one hundred medical students at the school, and during the past few years between twenty-two and twenty-six have passed out each year. After examination there follow two years in a hospital under European supervision before the qualified *médecin auxiliaire* is ready to work alone at an out-station. Most of them return to Dakar at intervals for refresher courses, and after ten years' service they return for further examinations.

The regulations of the service are framed in such a way as to make private practice by *médecins auxiliaires* almost impossible, unless they subsequently go to France to take a full medical degree. Individuals who have attained to a specially high standard may be given permits to practice, but such a case has not yet occurred.

In comparing this intensive training with that given in other parts of Africa, it has to be borne in mind that the Dakar students include a large number of Moors and half-castes, and, on the average, start their training at a higher educational level than those of Nigeria or Uganda, for example. Moreover, the climate of Dakar is more conducive to intensive study than that of more tropical regions. For the other French dependencies a medical school is

established at Tananarive in Madagascar on the same lines as that at Dakar, and another is starting at Ayos in the Cameroons, where a full four-years' course will follow a year's specializing at the *Ecole Supérieure* at Yaonde. In French Equatorial Africa a medical school is proposed in connection with the hospital at Brazzaville, to consist of a training school for *médecins auxiliaires* and a maternity school.

In British West Africa the question of establishing a training centre for medical practitioners in the Gold Coast and an auxiliary service of medical assistants was considered some years ago by a Committee appointed by the Secretary of State for the Colonies (Gold Coast 1928). Numerous difficulties were raised, particularly from the financial point of view, and the idea has been relegated to the background for the time being. In Nigeria a medical school was opened at Yaba in 1930. A system of training based on that of Great Britain, was legalized in 1934 (Nigeria 1935). The first two years are devoted to the usual pre-medical subjects at the Higher College, Yaba, and the third to fifth years are spent at the medical school itself, and the African hospital, dispensary, and health department in Lagos. The examinations, held after a five years' course, qualify for registration as a medical assistant, which gives the right to practice medicine, surgery, and midwifery in the government medical service. A medical assistant who has been registered for at least three years, one of which has been spent in an approved course of special study, and who has passed a further examination, can be granted a Diploma of Licentiate of the School of Medicine, Nigeria, to become registered as a medical practitioner in that territory. The training staff consists of a superintendent of the medical school and a teacher of pharmacy, but a prominent part is taken also by the staff of the African hospital in Lagos, and the medical research laboratories at Yaba. In fact, the time devoted to teaching by the government pathologists is a serious drain on their activities in research.

In Uganda the Mulago Medical School is the only centre of its kind in East Africa, and is likely to remain so for some time to come. Pupils are sent there from neighbouring territories, and already students from Zanzibar and Tanganyika have returned to the medical departments in these dependencies. In 1936, some

students from Kenya entered the school, which in Uganda is regarded as one of the most important organs of the department in its endeavour to improve the health of Africans. The training of medical attendants started at Mulago Hospital in 1913, and during the Great War the best of them formed the nucleus of the African Medical Corps. All training was suspended during the war, but in 1919 the institution of a government medical school was first suggested, when it was recognized that there was need for two classes of personnel: first those with medical qualifications who would eventually replace the Indian sub-assistant surgeons, and secondly attendants for purely nursing duties. Meanwhile, Makerere College was inaugurated in 1920, and advanced medical training began in 1923 with the appointment of Dr. H. B. Owen as medical tutor. The original course was of four years' duration, but in 1927 was extended to five years, and in 1936 to six. The syllabus approximates to that of London University, but naturally at present the standard of knowledge required, is not as high as that in a British university. In 1928 the medical school building was completed, and eight lecturers from the medical officers at Mulago were appointed. Students reside at Makerere for the first three years and then move to Mulago. Each year four or five students qualify, and the total number amounted to twenty-nine by the end of 1935. After qualification the medical assistants work in Mulago Hospital for a year, during which they act as house physicians or house surgeons, before proceeding to other parts of the Protectorate where they are slowly replacing the Asiatic sub-assistant surgeons. A system of registration was started in 1931.

In *South Africa* there are medical schools at the universities for training European doctors, but until very recently there were no training facilities for natives, with the result that the medical services in native areas have left much to be desired. The report of the Committee to inquire into the training of natives in medicine and public health (Union of South Africa 1928) made a number of important recommendations; among others, that facilities should be provided at the University of Witwatersrand, in a non-European branch of the existing medical school, for natives who should receive exactly the same training as Europeans, a pre-medical year to be spent at the South African Native College; native students

should be admitted from outside the Union, and loans should be provided from native funds to assist them to take the full course. It was recommended also that provision for training of health assistants and nurse-midwives should be made immediately, in addition to that of doctors. Although these recommendations have not been put into effect as they stand, a start was made in 1935 with the training of medical aids at the South African Native College at Fort Hare. This consists of a three-year course preceded by a preparatory year's training in science, and followed by a year's practical hospital and public health training in Durban. Although the courses bear some resemblance to those at Mulago and Yaba medical schools, it is emphasized that they are in no way comparable with those of the non-native medical students. The medical aid in South Africa is not designed to replace existing doctors, but to supplement the work of district surgeons in the outlying native areas, where the services of the ordinary medical man are seldom available. It is, in fact, believed that the employment of medical aids will tend to increase rather than decrease the work of the ordinary practitioner. The training is devised with a view to certain definite duties, which include preventive work, first-aid treatment of illnesses and injuries and the preparation of smears for the diagnosis of such diseases as malaria, leprosy, and tuberculosis. The training for the preparatory year was started in 1935 and the first batch of medical aids should come into service in 1940.

In the Belgian Congo, the advanced training of Africans as medical assistants or auxiliary doctors similar to those produced at Dakar, Yaba, and Mulago, is recognized as a necessity, and accordingly, a medical school was founded at Leopoldville in 1936. The course consists of four years' practical and theoretical work, followed by two years' qualifying at a hospital under full supervision. It is considered that, although a good education is necessary before entrance to this school, it is more important to give the future medical assistant a good moral grounding.

NURSES AND OTHER SUBORDINATE STAFF

For the training of African personnel of lower standard than auxiliary doctors, each territory has adopted its own system to

meet special requirements. It has been pointed out that the needs, especially in native areas, are common to nearly all the continent, and that there should be opportunity for co-operation between adjacent territories in providing training facilities. This perhaps has special application to Eastern Africa, where Northern Rhodesia and Nyasaland, for example, are at present unable to establish adequate centres individually. A medical and sanitary training centre, supported by two or three adjacent territories, would provide the most economical and effective way of ensuring a permanent supply of staff. The following notes concerning existing systems for the training of subordinate staff are arranged territory by territory in the usual order.

In the *South African Protectorates* training has been started with the aid of a grant of £10,000, which the gold mining industry made to the three territories in May 1934. In Bechuanaland, a scheme for the training of a few natives of both sexes each year as nurse-aids and dispensers is in operation at Serowe and Lobatsi Hospitals. Two of the women pass on every year for maternity and welfare training at Serowe, while the others proceed to outlying dispensaries, where their work is supervised by visiting medical officers. The idea is that they should give simple medical treatment and instruction on hygiene in the neighbouring villages.

In *Southern Rhodesia* the training of native medical orderlies at schools attached to the Salisbury and Bulawayo hospitals has been developed in recent years in connection with the extension of the medical services to rural areas. These orderlies are posted to the native medical units, where they take charge of the sub-hospitals or dispensaries. Schemes for the training of native women have been prepared, including the establishment of a training school for midwives in connection with the Bulawayo hospital.

In *Northern Rhodesia* the training of African personnel is hampered by lack of financial resources. In 1936, however, proposals were made for the opening of a temporary training school, and the initiation of systematic training for native sanitary inspectors. The principles of hygiene are taught in all schools, the Jeanes Schools being a centre for such teaching.

In *Nyasaland* hospital assistants receive a three-year training

at the Blantyre Mission Hospital (Church of Scotland Mission). During 1935 progress was made with the training of dispensers or dressers. The educational standard of the dresser has been raised and no boys under standard IV are accepted. The first part of the training consists of full-time work in nursing and ward duties under a nursing sister, who has to sign the probationers' cards of proficiency before they can qualify for promotion. They proceed to simple dispensing, the recognition and treatment of diseases and simple clerical work. Trained African sanitary inspectors are also much required, but it is held that little advance can be made without special facilities in the form of additional European sanitary superintendents, because the existing men have so little time to devote to training (Nyasaland 1935, *D.R.*).

The training of English-speaking African dispensers began in *Tanganyika* in 1927, a nine-months' course of theoretical work followed by nine months' practical hospital instruction being given. This has been extended, so that the medical apprentices now pass through a three-year course at Dar-es-Salaam. Revision courses have been held for some years, and small text-books on the various subjects in the syllabus, including elementary chemistry and physics, anatomy, physiology, medicine, surgery, hygiene, etc. are published. In future, candidates for this training will be required to have completed one year's secondary education, including elementary science and English. This course does not aim at the high standard of Mulago, since it is held that the territory's most pressing need 'is a large number of adequately trained natives capable of diagnosing and treating ordinary minor ailments and of recognizing serious cases which require to be sent to the larger hospitals for treatment. They may also be required to supervise the tribal dressers who work under the Native Authorities'. Several have been given scholarships to Mulago, and have gone to Uganda for this purpose. Training courses were instituted at Dar-es-Salaam in 1921 for urban sanitary inspectors, the teaching being given in English; vernacular courses were added in 1925 (Tanganyika 1927, *D.R.*). An experiment designed to produce a subordinate staff with knowledge both of preventive and curative work, has been recently set on foot in the Lake Province, where sanitary inspectors are instructed in medical work at the Mwanza

native hospital, and tribal dressers are taught rural sanitation methods at the health office.

The tribal dressers, who in Tanganyika provide the staff for the numerous dispensaries under the native administrations, were formerly trained at a number of centres, but the teaching is now being improved by centralization both in the Western and Lake Provinces, the latter having a special school for tribal dressers at Mwanza. At the same time an effort is being made to increase the numbers to 1 per 10,000 of the population. The object is to have one-third more dressers than are actually required at the dispensaries, so that every tribal dresser is free from duty for one year in every four in order to attend refresher courses. The training lasts eighteen months and includes clinical work in the hospital, full instruction in the use of the microscope and in preparing slides for diagnosis, but not much theoretical study. Although literate, the tribal dressers do not all speak English; their duties are to treat minor ailments, administer first-aid in the larger village communities, to recognize cases of illness which are beyond their power to treat and to see that these attend a dispensary or hospital. (Tanganyika 1935, *D.R.*).

In *Kenya* many of the dressers who staff dispensaries in native areas at present receive their training at district hospitals, but plans are being made for a three- or four-year course at the African Hospital, Nairobi, and in 1936 there were twenty-one learners in training at the medical training depot. Dispensary health workers are to receive practical training under European sanitary inspectors.

In *Uganda*, junior nursing orderlies receive one year's training at Mulago, followed by a year under a European nursing sister either there or at one of the district hospitals. After passing an examination the student may take the senior course, which involves another twelve months' work. This training is open to both boys and girls. The numbers are limited to twelve in the junior class and six in the senior; this is less than in former years, when forty nursing orderlies were produced per annum, but the standard of training is higher.

Two schools for the training of midwives are in existence, one at the Lady Coryndon Maternity Training School controlled by the Church Missionary Society, and one at the Nsambya Maternity

Training School controlled by the Mill Hill Catholic Mission. Both have attached to them a large number of rural maternity centres staffed by African girl midwives trained at the schools. The course given covers two years' theoretical and practical training. A special course for the training of African sanitary inspectors was begun at Mulago in 1936, and has attracted a very good type of student. A course of training for African artisans in simple well construction and the protection of water-supplies was inaugurated in 1935.

In *Nigeria*, special courses are arranged for nurses, dispensers, and other subordinate African staff, as laid down in a special publication (Nigeria 1930). For nurses, who can be trained at several of the African general hospitals, the complete training takes three years, before promotion as second-class nurses. To begin with, a six-months' series of elementary lectures and demonstrations is provided, after which most of the instruction is in the wards and out-patient departments. For midwives the length of training is two and a half years, including the same six months' preliminary course in general nursing. Infant welfare work is associated with that in midwifery. Dispensers are mostly trained at the School of Pharmacy, Lagos, and a three-year course is followed by the students, who are posted at a training hospital for a course of account keeping, etc. Laboratory attendants similarly have a three-years' course, with a fourth year, where possible. The training of sanitary inspectors has been especially developed in Nigeria, and a centre at Ibadan was completed in 1932, largely through a grant from the Colonial Development Fund. The course is two years in length, and up to 1936 some twenty-five Africans had been through the school, which also serves as a demonstration centre of hygienic methods of living for the local community.

In the *Gold Coast* a cadre of eighty nurse-dispensers for village dispensaries is being established, through the special training facilities at the Gold Coast Hospital. Midwives are trained at Accra Maternity Hospital. Four nurse-dispensers complete their training every year, and it is hoped that, with the help of members of the Gold Coast Red Cross, they will make possible the formation of health units in all outlying areas, the nurse-dispenser giving first aid and simple treatment, the local teacher or catechist being

trained in hygiene and sanitation, and his wife in maternity and child welfare. It is expected, however, that an expansion of the qualified medical staff will be necessary to provide sufficient supervision for these health units. A school for sanitary inspectors was reopened at Accra in 1934, and the training of village overseers was started in 1935 by health officers in Kumasi and Tamale, for sanitary work in rural areas.

In *Sierra Leone* the Connaught Hospital at Freetown is the training centre for nurses, midwives, and dispensers throughout the territory. Some of the trained men and women engage in private practice, but the majority remain in government service. Training courses for sanitary inspectors are also given in Freetown, and recently a system of refresher courses has been introduced; a maternity training centre will be included in the new maternity hospital at Freetown, when it is completed (Sierra Leone 1936, *D.R.*).

In *French West Africa*, the Medical School at Dakar, in addition to training the *médecins auxiliaires* (p. 507), provides special three-year courses for dispensers and midwives, and a two-year course for *infirmiers*, in all of which students spend a large part of their time in practical duties at the *Policlinique* and native hospitals.

In the *Belgian Congo* the principal hospitals serve as training grounds for nurses, dispensers, etc., as in the British and French territories, and in addition the missions and auxiliary services have important functions in extending medical work to the villages through the medium of trained or partly trained native men and women. For example the *Croix-Rouge du Congo*, in its work in Uélé, specializes in the training of nurses and midwives, usually the daughters of chiefs.

HEALTH PROPAGANDA

Health propaganda is carried out through many agencies, of which medical departments must necessarily be the principal. The subordinate African personnel, and particularly the health demonstrators trained at the Jeanes Schools, are also expected to spread knowledge of hygienic principles. Another means to this end is the organization of exhibits and health weeks, in which the Nigerian

medical department has been conspicuous. As soon as a sufficient proportion of the population has received some instruction, it is possible to utilize literature.

Posters are already widely used, particularly in Tanganyika. Literature is strikingly represented by *The Book of Civilization* arranged by Dr. A. R. Paterson (1936 and 1938). This is in two parts, the first on cleanliness, health, and the care of children, and the second on forests, land, cattle, and improved methods of farming. The cinematograph and broadcasting likewise play an important part in health propaganda, but this subject can hardly be drawn within the scope of the present volume, and is considered more fully in Chapter XVII of *A Survey of Africa*.

CHAPTER XVI

HUMAN DISEASES

INTRODUCTION

THIS chapter does not pretend to be in any way exhaustive. A full account of human diseases in Africa could be prepared only by a body of experts, and would be unsuitable for the present purpose, which is to indicate briefly the ways in which the study of human disease relates to other branches of science.

While the African is subject to most diseases which are known in temperate regions, he is particularly a sufferer from others which are unknown or have disappeared wholly or partially from Europe, and are now looked upon as 'tropical diseases'. These have been classified most commonly according to their methods of transmission, but for the purposes of this survey and to emphasize as strongly as possible the methods by which they can be controlled, a better grouping would be as follows:

A. Those diseases which are primarily due to the conditions of life of primitive agricultural peoples, and which may be expected to disappear with the introduction of improved social conditions and communal organization. Such diseases are malaria, blackwater fever, the jungle type of yellow fever, sleeping sickness.

B. Those diseases which are primarily due to the existence of insanitary conditions, and which may be expected to disappear with the introduction of improved housing, water-supplies, conservancy, etc. Such diseases are plague, relapsing fever, typhus, tuberculosis, leprosy, helminthiasis, typhoid, dysentery, pneumonia, and yaws.

C. Those diseases, the spread of which is largely due to ignorance. Among such the most important are the venereal diseases.

D. Those diseases which are, or are suspected to be, due to mal-

nutrition, and may be expected to disappear with an improved standard of living. Such diseases are tropical ulcer, scurvy, pellagra, beri-beri, xerophthalmia, and a number of other conditions.

In the following pages the above order has been adhered to as closely as possible, but in certain cases, as in yaws and syphilis, the symptoms of, and research on the diseases are so similar that they have had to be considered under one heading. Diseases which result from malnutrition are considered not here but in the section of Chapter XVII on food and nutrition.

RESEARCH AND CONTROL

MALARIA

It is often stated that malaria is holding back the advance of both black and white in Africa more than any other single factor —that it ought to be eradicated, controlled or at least mitigated; but for the purposes of this account the aspects of the problem which are implied by the word 'control' cannot be considered satisfactorily because conditions, and, therefore, means of control, vary greatly from place to place. It is possible only to consider the general relations of malaria to human progress by stating the views of some experts purely objectively and by referring to a few important publications. Expert opinion can be quoted in support of two policies; that which seeks to eradicate the mosquito by drainage or by oiling waters, and that which concentrates on killing the parasites in the sick person by quinine or other drugs. It is not always recognized, especially among the general public, that different workers write about different places, and that what is right for one place is quite wrong for another. The League of Nations malaria reports (see later) emphasize that each locality must 'work out its own salvation' in the choice of anti-malarial measures, and the necessity for local variations of method is now recognized.

Sir Ronald Ross, after his discovery in 1897 that part of the malaria parasite's life cycle is passed in *Anopheles*, pointed out that this knowledge provided an entirely new method of prevention through the destruction of the mosquito. The Ross Institute,

which is now under the direction of Sir Malcolm Watson and has recently been incorporated with the London School of Hygiene and Tropical Medicine, has been the centre for developments which have arisen from the initial discovery, and has collaborated with entomologists and medical men throughout the world. Some conclusions now reached are as follows. To eliminate the disease in any area it is not necessary to destroy all *Anopheles*, even of the dangerous species. Drainage and agriculture are the old and proved methods, but research since Ross's discovery has shown that these may lead in some conditions to increase rather than decrease of mosquitoes and malaria; for example in many places drainage by open ditches is dangerous, since the environment thereby produced is made more favourable for the malaria mosquitoes than some kinds of swamp and most wet forests. Other examples are the selection of non-malarial sites for new houses, and the removal of old houses to new and healthy sites; the use of anti-malarial oils or paris-green to destroy mosquito larvae; the preservation or destruction of forest or bush, as may be appropriate to the locality; changing the chemical composition of water, as in flooding dangerous coastal swamps with salt water, or converting brackish water areas into fresh water, as practised with success in Holland.

Sir Malcolm Watson (1930), who has studied malarial conditions in many parts of the world, including Africa, has summarized the malaria policy of the Ross Institute and (1935) in his Finlayson Memorial Lecture at Glasgow has described the great progress achieved in the control of malaria since Ross's discovery. There are, however, many parts of the world, formerly infected with malaria, where the disease has practically ceased to exist as a result of normal agricultural development without special anti-mosquito campaigns; in many areas *Anopheles* have remained common after the disease has disappeared. Europe provides such examples, which were discussed at length by Dr. L. W. Hackett in his Heath Clark Lectures of 1934 (published 1937).

With regard to Africa as a whole, the upholders of treatment as the chief method of attack have stressed that since it is impossible to eradicate *Anopheles* everywhere, its eradication from limited areas might do more harm than good. The majority of Africans

contract malaria within their first few years, and, if they survive, obtain a certain degree of immunity which lasts throughout life, but this immunity is to one local strain of the disease rather than to malaria as a whole. If the disease is eradicated from an area and children grow up without attaining partial immunity, and subsequently move into an infected area, they are liable to contract the disease in a more serious form. According to this view, if it is conceded that the disease cannot be stamped out completely, the great aim must be to develop immunity to all forms of the disease by a better standard of living, together with improved therapeutic methods. The report on Principles and Methods of Anti-malarial Measures in Europe (League of Nations 1932a), prepared by a number of eminent malariologists and originally drafted by Colonel James, stresses the improvement of the standard of living. This report was prepared expressly with regard to European countries, but it clearly has applications in other parts of the world. The same principles have been adopted wholeheartedly as applicable to tropical conditions by some African officers, notably by Dr. A. R. Paterson (1928a) in Kenya.

Turning to therapeutics, the effects of quinine and new synthetic drugs, mostly prepared in Germany, have been intensively studied during recent years. Many of these, which seemed at first to be of supreme importance, are losing favour after trial, but a steady flow of new drugs is being produced. The Report on Therapeutics of Malaria (League of Nations 1933a) points out 'that the therapeutics of malaria, like every other aspect of the disease, is much more a local and individual problem than has hitherto been thought'.

In general, anti-malarial work in Africa is hampered by ignorance of what are the real effects of malaria. It is well known that over vast areas of the country practically the entire African population above one year of age harbour malaria parasites in their blood continuously, but as yet little knowledge is available as to the effects of this condition at different age-periods in terms of sickness, mortality, general well-being, and working capacity. Inquiry is urgently needed with the object of ascertaining to what degree this parasitic infestation is harmful, and to discover at what age-period of life curative or preventive action would be most

helpful. The importance of such work was stressed by Colonel James (1929) who visited East Africa in 1928 to advise on anti-malarial measures. He concluded that at least a million, and probably many more, people in Kenya are constantly suffering from malaria and not more than one in 60,000 is within reach of a medical practitioner. In the native reserves of Kenya the disease is endemic in from 30 per cent to 80 per cent of the people; in the Eastern Province of Uganda the percentage of children with parasites in their blood was found to reach 80 per cent and of those with enlarged spleens 96 per cent. He concluded that the only way to improve the situation is by education and by raising the standard of living. The same method of attack applies to practically all diseases, and malaria cannot be tackled separately except in isolated areas, such as townships like Kampala, where mosquito control measures are possible. The special malaria research unit in Tanganyika has published important information in its two reports (R. Mackay 1935, and D. B. Wilson 1936), while other studies on malaria in African populations have been carried out by Barber and Ollinger (1931) in Southern Nigeria, and Thomson (1935) in Nyasaland.

Another important work on malaria, concerned particularly with the white farming community in South Africa, is that by Professor Swellengrebel (1931). Prophylactic use of quinine and screening from mosquitoes were found definitely to reduce the incidence of malaria: thus the spleen rate among children was 88 per cent in unscreened farms and 44 per cent in screened ones, even though the measures were far from perfect. Swellengrebel's recommendations include the formation of an administrative control unit and a research field station, the instruction of school teachers and future farmers' wives in the principles of hygiene and anti-malarial measures, and a system of medical examination of recruited labour before acceptance, so that malaria carriers may be detected and excluded. The prophylactic use of quinine and other drugs has special bearing on the health of non-native races in malarious districts and has been in dispute for many years. Evidence in favour of or against this practice produced by medical officers and others throughout Africa, seems to justify a definite investigation as to its advisability.

Anti-malarial work in French Africa, as in the British territories, is based on many kinds of policy, but, as mentioned above, conditions vary so much from place to place that in the present state of knowledge the problem is best attacked from many aspects. Professor Marchoux, the authority on malaria at the Pasteur Institute in Paris, considers that in most regions the best approach is to cure the sick and improve the standard of living, and considerable advances on these lines have been made in recent years. Meanwhile direct attacks against the mosquito vectors have been made in certain areas, mainly through the agency of the Rockefeller Foundation.

For the Belgian Congo some information on the incidence of malaria has been collected during the past five years. J. Schwetz, with the collaboration of Baumann, Peel, Droeshaut and Belhommet (1933, 1934), has published a long series of papers on the subject and among other authors may be mentioned P. Reyntjens, M. Sambon (1931–2), and R. van Nitsen (1933). In general it may be said that modern views of malaria control hold that in townships anti-mosquito measures offer the greatest hope of eradicating malaria, and these may also be justified in rural areas where special conditions such as concentrated agricultural development exist. In the greater part of Africa, however, malaria control must be limited for financial reasons to concentration on general methods for raising the standard of living combined with treatment of the sick where necessary, emphasis being laid on the fact that no statistical evidence of value has yet been brought forward to justify many of the unsupported statements made as to the important part played by malaria in increasing African morbidity and mortality, especially in childhood.

BLACKWATER FEVER

Little is yet known about the cause and cure of blackwater fever, beyond the facts that it is closely associated with malaria, and that where malaria prophylaxis is carefully carried out, blackwater rarely occurs. This disease has been associated mainly with non-native races, but more cases may occur among Africans than are recorded. Many suggestions have been made as to its nature and causes, but few have so far been put to experimental proof. Some

authorities maintain that the disease results from persistent serious attacks of malaria, some from excessive dosage with quinine, and others that it is due to a bacterium, while at one time it was thought that a specific protozoal infection might be involved. Blackwater is now regarded as a concomitant of malaria, though persons who were known never to have had malaria or taken quinine have suffered from it. Professor J. Gordon Thomson (1923 and 1924) studied the disease in Southern Rhodesia and summarized the knowledge then existing, and this work was continued during 1925 to 1929 by G. R. Ross (1932). A marked advance in the treatment of the disease was made by the introduction of blood transfusion, and further work on these lines has been done in Southern Rhodesia during the last few years. In particular the reticulocyte response to this method of treatment has been worked out at the public health laboratory at Salisbury. A society of blood-donors has been formed for this purpose. Blackwater fever is found chiefly amongst prospectors or others whose occupation exposes them to mass infection by malaria-carrying mosquitoes in circumstances where the living conditions are unsatisfactory. The number of fatal cases in Southern Rhodesia from 1930 to 1935 ranged from twelve to seventeen annually. In the Belgian Congo it has been proved that the majority of cases occur among Europeans who live in malarial districts, but who do not take quinine as a prophylactic. Professor J. W. W. Stephens, aided by a grant from the Leverhulme trustees, is to prepare a treatise on the disease in its historical and other aspects.

YELLOW FEVER

Yellow fever, also a mosquito-borne disease, is to some extent capable of similar methods of investigation and control. Its history and epidemiology are described at length by H. R. Carter (1931) and the many problems raised by the disease in Africa are discussed by Ricardo Jorge (1934). It has been conclusively proved, in South America, that *Aëdes* is not the only vector, since outbreaks have occurred in localities where it is absent. In such cases the vector appears to be some other mosquito, perhaps *Anopheles*. Yellow fever is therefore now divided into two classes:

(1) *Urban*, which is carried by *Aëdes*, is generally recognizable clinically, is normally a house infection, is often epidemic and has a high mortality; (2) *Rural* or *jungle*, which may or may not be carried by *Aëdes*, is often not recognized clinically, is associated with forest occupations and not with houses, is sporadic and has a low mortality.

Study of its geographical distribution have been largely carried out by the International Health Division of the Rockefeller Foundation, which maintained until 1934 a yellow fever laboratory at Yaba near Lagos. This laboratory has been taken over as part of the Medical Research Institute of the Nigerian Government, which maintains, with the assistance of a grant from the Rockefeller Foundation, a yellow fever unit under Dr. Merrett. The chief method in studying distribution consists in examining specimens of blood from persons selected at random in order to ascertain what proportion of them have been infected with the virus. Persons who have had yellow fever, or who have been infected with the virus without having the disease, become immune. Their blood, when injected into white mice, protects these animals against a dose of virus which is ordinarily fatal. This is called the 'mouse protection test'. The survey work already completed has resulted in maps and descriptions indicating the endemic distribution of the disease. Roughly this covers a wedge-shaped area extending on the west from Nigeria, the Gold Coast, Sierra Leone, the Gambia, Liberia, and French West Africa, through French Equatorial Africa, the northern and central part of the Belgian Congo to the south-western part of the Anglo-Egyptian Sudan, and Uganda. Many of the areas where the mouse protection test has proved positive, but no clinical cases have been found, are termed 'silent'. They are possibly infected with the rural type of yellow fever mentioned above. Recent work in South America has shown, however, that cases of yellow fever do occur in such silent areas, so these areas may be sources of infection spreading to towns and villages where the disease appears in its dangerous urban form. Accordingly much importance has been attached to fuller investigation of the affected areas, especially in Uganda, where the dense population presents the greatest dangers, and to this end the Rockefeller Foundation in 1937

assigned three members of its yellow fever staff to Uganda, to occupy the Human Trypanosomiasis Laboratory at Entebbe, recently vacated by Dr. Duke (*see* page 485). It is important to recognize that the mouse protection test does not prove the presence of the virus, but only indicates that the individual has at some time had yellow fever, which may subsequently have died out from the area. It serves to define the extent and concentration of immunity in various age-groups of a population, but gives no indication of the state of affairs at the moment. Hence the finding of actual cases is important.

Intensive research is being conducted for actual clinical cases of yellow fever in the silent areas where the mouse protection test indicates the existence of the virus, but from which, up to the present, the disease itself has not been recorded. One of the enigmas of yellow fever arises from the fact that during epidemics many people are infected and become immune without apparently showing clinical symptoms. Therefore, attempts are being made, notably in the Anglo-Egyptian Sudan, to isolate the virus from suspicious cases in order that its characters may be fully studied. Apart from detection of the virus, the existence of the disease may be proved by microscopical post mortem examination of the liver, and for this purpose a special technique has been applied with marked success in South America. A special instrument, the viscerotome (Morgan 1935) enables the layman to remove specimens for dispatch to pathological laboratories without the necessity of handling the corpse or tissues, and with the minimum mutilation of the body. In South America the viscerotome service has proved the existence of yellow fever in many places, and enables action to be taken to prevent emanation of the virus from known infected points. It has shown, moreover, that the silent areas are silent, not because fatal cases do not occur, but because symptoms are not typical. The information can be obtained by the viscerotome without posting trained medical staff in every locality where the disease is suspected. A viscerotome service has been inaugurated in the larger centres of population in the Gold Coast (League of Nations 1936, p. 76), and in West Africa it is hoped that valuable data may be obtained and the services be extended. The chief difficulties are (1) the objection of Moslems to interfering with

corpses, (2) the absence of registration of deaths, and (3) the lack of staff for field work.

The introduction of air travel has created the danger that the disease may spread from endemic centres, especially in West Africa, where a large proportion of the population seems to possess some immunity owing to the prevalence of the disease, to East and South Africa, and even to Asia, where the mosquito vectors are abundant, and disastrous epidemics might occur among populations having no immunity. The spread of infected mosquitos can be prevented by fumigation, but the principal danger comes from passengers embarking during the incubation period of about six days. The special commission on yellow fever of the Paris International Office, under the Chairmanship of Colonel James, has stressed this danger, and it has been discussed extensively at the Pan-African Health Conferences in South Africa (League of Nations 1933b and 1936).

The disease is particularly prevalent in Liberia, which forms a permanent reservoir for its spread to adjoining territories. Work in Liberia by the Rockefeller officers shows that the majority of children contract the disease, but among them the mortality rate is only 5 per cent and complete immunity results. Among white men in West Africa, however, who contract yellow fever as adults, the mortality is more than 90 per cent. Hence there is a danger of the disease being erroneously regarded as one chiefly affecting the non-native population.

The International Sanitary Convention for Aerial Navigation of 1933 has been ratified by a considerable number of states. This convention, to which all governments in Africa have agreed to adhere, was prepared by the permanent committee of the *Office International d'Hygiène Publique* in Paris, and is designed especially to prevent the risk of yellow fever spreading from its present endemic centres. The fact that some governments are not prepared to accept positive results obtained by the mouse protection test as proof that yellow fever is present in the silent areas, adds emphasis to the need for proving clinical cases.

In towns and other localities where the disease has occurred, continuous and, whenever possible, permanent measures are taken for reducing the prevalence of the mosquito vector. These have

been successful, particularly where it has been possible to introduce a piped water-supply. Freetown, for instance, which used to be a hot-bed of yellow fever, has had very few cases since the introduction of a piped water-supply more than twelve years ago.

Again in the Belgian Congo, at the ports on the lower river, especially Matadi, a special department in charge of water-supplies and anti-mosquito work was established after the last epidemic of yellow fever in 1927–8, with the result that *Aëdes* and yellow fever now rarely occur. Other measures, such as the British plan of separating the European from the native quarters of towns, have had their effect. But there have been some calamities also, notably the yellow fever epidemic in Bathurst in 1934, when four Europeans, including the Colonial Secretary, died from the disease. In this outbreak it was manifest that the infective zone was in the European residential area, and subsequent investigations by Dr. Findlay showed that the reported cases were only a fraction of those which must have occurred.

Preventive vaccination against yellow fever was introduced in America by Sawyer and his collaborators. Two methods of vaccination are now being applied extensively, that of Sawyer, Kitchen, and Lloyd (1931) with modification by Pettit and Stefanopoulo (1933), and that of Laigret (1934). Dr. Findlay (1935) of the Wellcome Research Institute in London, who was sent to New York by the Colonial Office to study the Sawyer technique, has vaccinated by the first method more than 900 persons proceeding to West Africa. In French Senegal, Dr. Laigret has vaccinated more than 3,000 Europeans by the second method, using vaccine prepared from mouse brains at the Pasteur Institute in Dakar. The results from either method are not always satisfactory, since the reactions of individuals to yellow fever differ so markedly, but yellow fever vaccination has undoubtedly produced results which warrant its extended use among Europeans.

SLEEPING SICKNESS

The severe epidemic of sleeping sickness in the four years 1901–1905, when some 300,000 people died of the disease in the immediate neighbourhood of the Victoria Nyanza, has stimulated much research and many experiments in control, but knowledge

is still far from complete. The main problems and results of research have already been outlined from the entomological point of view in Chapter X, and the following remarks refer principally to the medical aspect. The fundamental work on sleeping sickness was carried out by Sir David Bruce and his colleagues during the Royal Society Sleeping Sickness Commissions at the beginning of this century, and the conclusion that the disease is caused by a trypanosome and conveyed by a species of tsetse fly was first announced by Bruce in April 1903. Since those early days important work, carried out under the auspices of the League of Nations International Commission on Human Trypanosomiasis (League of Nations 1924, 1925, 1927, 1928a and b, 1930a) has laid the foundations for the numerous studies now in progress. Other publications of a general nature, dealing especially with British territories, are the report of the East African Commission (1925), which paid particular attention to sleeping sickness and demanded a scientific survey in all the East African dependencies, a report by Dr. (now Sir Walter) Johnson (1929) on the organization and methods of trypanosomiasis control, and by the Tsetse Fly Committee of the Economic Advisory Council (1933 and 1935), which has devoted attention to the treatment of human trypanosomiasis and summarized recent developments. The question of co-ordination of research in the East African territories has been discussed at meetings arranged by the Conference of East African Governors (1934b and 1936b).

For purposes of research there have been three important centres in the British dependencies devoted especially to sleeping sickness: (1) the Human Trypanosomiasis Institute at Entebbe, Uganda, was established in 1927 under Dr. Duke at the conclusion of the Sleeping Sickness Commission. It was financed by the three East African Governments, and was closed down finally in 1935 on Dr. Duke's retirement; (2) The Sleeping Sickness Branch of the Nigerian Medical Department has a laboratory at Gadau in the Northern Provinces with a research staff of a medical officer, an entomologist, etc.; (3) The Sleeping Sickness Research Unit in Tanganyika has a laboratory at Tinde in Shinyanga district, under Dr. Corson; this is now financed by a special grant from the Colonial Development Fund.

The work in Uganda and Nigeria has been concerned primarily with the form of sleeping sickness caused by *Trypanosoma gambiense* and conveyed by the tsetse fly, *Glossina palpalis*, to which must be added *G. tachinoides* in Nigeria. In Tanganyika the other variety of the disease, caused by *T. rhodesiense* and conveyed by *G. swynnertoni* and *G. morsitans* is the major problem; the area of infection is enormous and huge tracts of country are rendered uninhabitable. Studies in that territory have, of course, been closely associated with the tsetse department under the late Mr. Swynnerton (1936). A summary of work at these three centres may serve to supplement the account of research on tsetse flies in Chapter X and of animal trypanosomiasis in Chapter XIV.

The results from Uganda have been published in annual reports (Uganda 1933–4, *A.R.*) and in numerous scientific papers, and the following salient conclusions have been reached. Regarding the transmission of the disease, infection by trypanosomes exerts no apparent effect on the longevity of *G. palpalis*, and there is no difference in the susceptibility of the two sexes of this fly to man's trypanosomes. A mass of evidence has been produced to show that there occur in man in Uganda and elsewhere strains of *T. gambiense* which, from their first isolation, are non-transmissible by *Glossina*. *G. morsitans* has been shown to be a better transmitter of the trypanosomes of man than *G. palpalis*. Repeated cyclical passage through *Glossina* does not necessarily increase the transmissibility of a strain of trypanosomes. Old laboratory strains of man's trypanosomes have been found to be non-transmissible by tsetse; a strain of *T. gambiense*, maintained for fifteen years in laboratory rodents, was tested on man and found to be readily pathogenic. *T. rhodesiense* has been transmitted readily from host to host by the direct method, by *Stomoxys* and also by feeding infected prey to carnivorous animals.

The part played by domestic and wild animals in serving as reservoirs for human trypanosomes has likewise been examined, with the following results: natural immunity against *T. gambiense* in sheep and goats varies from complete immunity to a degree of susceptibility in which the trypanosomes may be a contributory, or even the direct cause of death. Between these extremes there usually exists partial immunity, which prevents the transmission

of the trypanosome by tsetse, after a period of a year or fifteen months. Immunity may also be acquired by sheep and goats against *T. gambiense.* Results similar to these have followed experiments with *T. rhodesiense*, which loses its power of infecting man still more readily than *T. gambiense*, when maintained for long periods in animals. Maintenance in guinea pigs is especially prone to produce this change. Regarding wild animals, *T. gambiense* in its East African form is difficult to introduce into antelopes, and once introduced tends to die rapidly. *T. rhodesiense*, however, is less susceptible; it has practically no effect on bushbuck and reedbuck, but is pathogenic to oribi and situtunga; it has been shown to survive in transmissible form in bushbuck for two and a half years and in a hyæna for twenty-two months. The domestic fowl has been eliminated as a danger in the spread of human trypanosomes.

Experiments by Dr. Duke on the prophylactic use of drugs have led to the conclusion that an injection of one gram of Bayer 205 will protect against *T. gambiense* or *rhodesiense* for at least three months. Between seventy and eighty native volunteers have been used in these experiments in the past few years; there has been no mishap and the results have opened up new possibilities in the control of sleeping sickness (see later). Although the trypanosomiasis institute at Entebbe no longer exists, work on kindred problems has continued in Uganda. In particular Dr. Mellanby has been studying the bionomics of *G. palpalis*, with a grant from the London School of Hygiene and Tropical Medicine (*see* Chapter X).

From the above it appears that two important conclusions have resulted from Dr. Duke's work. (1) Game animals can, under certain circumstances, serve as reservoirs of human trypanosomiasis, but so long as the human reservoirs can be kept separate there is no need to exterminate the game. (2) Bayer 205 is a valuable prophylactic. For the rest, in this area, sleeping sickness is now limited to certain foci and is certainly not of the same importance as it is in the French and Belgian territories. Therefore, as Dr. Duke has pointed out, work on sleeping sickness should not obscure that on other diseases.

At the Tinde laboratory in Tanganyika Dr. Corson has carried

out numerous experiments, mainly on the transmissibility of human trypanosomes by animals. These have confirmed and extended Dr. Duke's work, especially in regard to the part played by animals as a reservoir for *T. rhodesiense*. In addition, the sleeping sickness branch of the medical department has carried out extensive surveys, and has established means of ensuring that very few cases escape being reported.

In Nigeria, since the establishment of the sleeping sickness branch of the medical department, the wide distribution of the disease has been demonstrated, and evidence has been brought forward that it has increased in recent years. It is presumed that much of the population, especially in the Southern Provinces, has acquired some immunity to the local strains of trypanosomes, but that the recent increase in motives or facilities for travel has led to contacts with new strains which have often caused virulent epidemics. There have been examples of this in the middle belt, where gold mining has stimulated migration, and also near Port Harcourt in the south. Although *T. gambiense* is probably the only causative organism, three types of the disease can be recognized, which seem to depend on the degree of immunity which has been attained by the people concerned. First there is a type showing general weakness, but not a high death rate; the patients may suffer for many years and their resistance to other diseases is lowered, so that when death occurs it usually appears to result from other causes. Secondly there is a toxic type in which death, when it occurs, follows acute high temperature; and thirdly there is the classic disease characterized by sleeping and mental trouble, symptoms which are absent in the first two types. It has been estimated that there must be nearly a million cases in the Northern Provinces of Nigeria alone, and although curative treatment has been successful, it is recognized that treatment of this number every year would be impossible. Hence, protective measures involving a reduction of the man-fly contact by methods of communal clearing, and movement and concentration of population, provide the most hopeful line of attack. Research, centred at the Gadau laboratory has been concerned chiefly with tsetse flies, and is outlined in Chapter X. Application was made in 1936 for a much increased grant from the Colonial Development Fund to expand

sleeping sickness control, partly by improving the existing treatment service and partly by a protective campaign of communal clearing, movement, and concentration of population. The cost of this second part of the scheme is to be defrayed by a five years' free grant from the Colonial Development Fund, whilst the cost of improved treatment is to be defrayed by the Nigerian government (Nigeria 1936, *D.R.*). There is a trypanosomiasis bureau in Southern Rhodesia which not only correlates the work of all government departments on this subject, but has a special laboratory, in charge of Mr. Bevan, a Beit Fellow. As in East Africa the disease is by no means so common now as in past years. In 1935 a survey, involving careful examination of natives, was made in the Sebungwe area to the west of Goheve. Although the disease was formerly known to be present, no cases of sleeping sickness were found.

With regard to control, the East African sub-committee of the Economic Advisory Council (1935) described three types of possible measures: (1) administrative methods, such as the evacuation of population from an infected area, the control of movements of population (in search of work, etc.), the clearing of water places, and the concentration of settlement; (2) the control of tsetse flies; and (3) control by chemotherapy, that is to say, treatment by means of various drugs.

The first of these methods is followed in Uganda, the Congo, and Nigeria. As mentioned above, the usual infection of *T. gambiense* is conveyed by *G. palpalis*, and in the drier areas of Northern Nigeria by *G. tachinoides*, both of which species must have damp and shade for breeding. Hence the most effective way of control, which has been widely employed in Uganda and the Congo, is to remove natives from infected banks of rivers or lakes, and to allow them to make watering and washing places only in specially cleared strips. Wide stretches of shore along the great lakes and rivers are thus closed to native occupation. The fly does not die out in the absence of human beings, since it can obtain abundant food from wild mammals and reptiles, but in the absence of the human reservoir the sleeping sickness infection is lost after some time. Thus in Uganda population has recently been returned, under close control, to many of its former holdings along the lake

shores, and fresh cases of sleeping sickness have not occurred. In such areas, however, there is always the potential danger that some immigrant person with sleeping sickness may reinfect the fly, thereby causing a new epidemic. It is important, therefore, that the population should be separated from fly as much as possible, and the usual policy is to allow reoccupation of lake shores and other tsetse-infected areas only when the population is sufficiently dense to maintain proper clearings. Food crops likely to shelter fly in close proximity to tsetse-infected bush are prohibited.

The bearing of such means of sleeping sickness control on the improvement of agriculture is stressed by the measures which are being introduced in Northern Nigeria to concentrate the population, and introduce mixed farming (*see* Chapter XIII). Again, in Tanganyika the control of infection by *T. rhodesiense* is coming to depend mainly on settlement and reclamation schemes which have been advocated especially by Maclean (1930) and the Conference of East African Governors (1934b).

The second method of control, involving efforts to reduce the incidence of fly by clearings, traps, etc., has been discussed at length in Chapter X. In chemotherapy, great progress has been made recently in the use of the two drugs Germanin (Bayer 205) and Tryparsamide, an arsenical preparation. Although the effects vary with different species and strains of trypanosomes, in general germanin is effective in the initial stages of the disease and tryparsamide in the later, and for general application in stricken areas a combined method of treatment has been applied with much success.

Curative methods have been especially developed in the French and Belgian colonies, for which the system of *équipes de prospection et traitement* has been described in Chapter XV. For the Cameroons, where sleeping sickness has increased steadily during the past ten years, some results have been given by Jamot (1930) and Millous (1935). During the year from October 1933 to 1934, 546,000 natives were examined, of whom 61,800 had the disease, but only 3,300 of these remained carriers of trypanosomes after treatment. The sleeping sickness work is combined with an attack on other diseases and the collection of valuable demographic statistics. In the Belgian Congo the state service has concentrated on sleeping

sickness, and until 1919 this disease absorbed most of its attention; since that date endemic complaints such as yaws, syphilis and dysentery have been combined with the sleeping sickness campaigns. The intensity of this work is indicated by the fact that more than 3,000,000 people are examined annually, all positive cases being recorded and persuaded to attend regularly at the numerous treatment centres. For the period 1930–4 the result has been a decrease of new cases to about 50 per cent, the actual figures being as follows:

	Natives examined	*New Cases*	*Percentage of new cases to natives examined*
1930	2,779,448	35,562	1·2
1934	3,824,097	24,010	0·63

The FOREAMI represents a unique organization for anti-sleeping sickness work, through which the population in the Bas Congo has been examined regularly since 1931, all cases being treated. In 1934 more than 38,000 lumbar injections were given through this agency and the endemicity of the disease appears to have been reduced from 2·45 per cent in 1931 to 0·97 per cent in 1934. Dr. Trolli considers that the natives in the Congo have now as much faith in the curing of sleeping sickness as they have in that of yaws, which renders treatment comparatively easy.

In Nigeria a system of inspection and treatment has been partly adopted from the French and Belgian territories. The campaigners are divided into (1) a survey party, which makes a census of the area in question, examines the glands of every individual, makes blood slides of suspected cases, and marks all individuals giving a positive result, and (2) a treatment party, which follows after and injects with germanin or tryparsamide in every positive case. One medical officer has with him a native nurse and about twenty microscope boys, who are said to prepare and examine blood slides more efficiently than Europeans. In Nigeria some 32,000 patients were treated in 1933, 52,000 in 1934, 84,000 in 1935, and 62,021

in 1936. Similar methods have been applied in the recent outbreak of sleeping sickness in the West Nile District of Uganda.

Though it is convenient to divide the methods of control into categories as above, in practice more than one method is usually employed. Thus, in controlling the epidemic just mentioned blocks of bush have been isolated by large clearings on the riverside and flies are being eradicated from each by hand-catching and trapping. This method gave excellent results when applied by Symes to the tributaries of the Kiya River in Kenya (Symes 1936). In the French territories again, although efforts have been concentrated mainly on cure by drugs, clearings of river banks, etc. are made in suitable conditions. In the Anglo-Egyptian Sudan, also, the Government has organized sleeping sickness campaigns in recent years, whereby the disease is claimed to have been practically eradicated from the Mongalla and Bahr-el-Ghazal provinces. The measures adopted have consisted of cutting bush along roads and streams, concentrating the population on the cleared roadsides, long quarantine for suspected cases, and the establishment of sleeping sickness settlements for treatment.

PLAGUE

Plague is firmly established in parts of Africa and may spread to unaffected areas, with very serious results, unless strict precautions are taken. The main centres are in South Africa, where it appeared first in 1899 through infected rats escaping from ships, East Africa, especially Uganda, where it was probably endemic for a long period before European occupation, and West Africa, where several importations have been made at the harbours. Fortunately African conditions do not favour the contagious pneumonic form of the disease, but there are certain instances on record where pneumonic plague has occurred and has not been recognized until the contagion has spread, with fatal results. The mortality rate of bubonic plague amongst Africans has varied between 25 per cent and 75 per cent of cases in various epidemics.

The fullest recent description of plague in Africa is by Ricardo Jorge (1935a), who has also summarized the ancient and modern epidemics (1933) and given an account of the disease in Angola (1935b). The whole problem received attention at the Pan-

African Health Conference in 1935 (League of Nations 1936). It appeared that much of the extension of the veld epizootic, presaged at the previous Conference, had taken place. In the Union and countries on its northern and western borders the incidence of human plague is determined by epizootics among wild rodents, infection being for the most part direct from them, and to a less extent from domestic rats infected by fleas from wild rodents. In the more northern territories, such as Kenya, Uganda, and Tanganyika, the increased importance of domestic rats is apparent, but it is certain in some cases that wild rodents have also been infected. The fact that, in several countries, epizootics have occurred among wild rodents for considerable periods before their discovery, points to the necessity for systematic observation and also for co-ordination between adjoining countries.

The history of plague in South Africa, as summarized by Sir Edward Thornton (League of Nations 1936, p. 100) is as follows: 'From 1892 to 1905, plague was introduced at the ports and caused extensive outbreaks amongst domestic rodents and a considerable number of human cases in urban areas. From 1903 to 1905 striped mice (*Rhabdomys pumilio*) in the bush surrounding one or more of the ports became infected, and the infection spread slowly through the bush until it reached, in 1914, sandy country inland, where gerbilles were plentiful, when rapid spread all over the inland parts of the Union, with isolated human cases, occurred. During the period 1914–33, human cases were almost entirely infected from veld rodents, and domestic rodents were found infected in exceptional cases only. During 1934–5, with the breeding up of veld rodents owing to favourable seasons, numerous waves of infection occurred, resulting in an increased number of human cases. Further, domestic rodents became infected in a number of places.'

The fact that epidemics of plague are nearly always associated with increases in the population of rats or wild rodents opens up an important problem in the realm of animal ecology (*see* Chapter VIII). It is becoming recognized that these animal populations are subject to periodic fluctuations in numbers, first increasing to such a degree that there is food shortage and weakening of stamina, followed by disease epizootics. Meanwhile the flea population

increases accordingly, and on the death of the rodent hosts, the infected fleas transfer themselves to man or other animals.

In South Africa the recent work of Harvey Pirie and Murray at the Institute for Medical Research has shown that among at least some of these wild rodents this periodicity exists; therefore it seems probable that the small South African rodents fluctuate in numbers like the voles and lemmings in the northern hemisphere; that they normally die off every few years from diseases harmless to man; and that bubonic plague has spread among them and in some instances replaced these natural diseases, though in other instances the latter have reasserted their importance. Although human plague has not so far become very serious or widespread in Southern Africa, except in Angola, the area in which rodents have become endemically infected has steadily increased since 1921, which gives a sinister aspect to the situation.

In South Africa the Witwatersrand plague committee was established early in 1935. An assistant health officer and a senior rodent inspector were detailed to carry out inspection of the reef area, in which an epizootic had been notified. Their findings are published in the report of the department of public health (South Africa 1936, *D.R.*).

The possibility that plague in other parts of the continent has a periodicity, dependent on fluctuations in numbers of rodents and their fleas, has been considered by C. B. Symes (1930), who reviewed the outbreaks in East and West Africa, and concluded that there is at least an indication of periodicity, the main epidemics having been in 1912–13, 1916–17, 1920–1, and 1923–4.

In East Africa the centre of plague infection is Lake Victoria, where its spread since the establishment of shipping in the lake ports has paralleled the medieval epidemic which spread around the Mediterranean. In Uganda the seriousness of the disease can be judged from the fact that in the twenty years up to 1932 some 52,000 deaths are estimated to have taken place from plague, the climax being in 1929 during which year there were over 5,000 deaths. In 1930 Sir Edward Thornton visited the Protectorate to advise on control measures, and since 1932 there has been a considerable decrease, followed by a slight rise in 1935. It is feared that the decrease after 1932 may have been due not so much to the

anti-rat campaigns, the use of cyano-gas in huts and other sanitary measures, as to a natural decline in the epidemic wave. Probably associated with the plague area in Uganda is a small centre in the Belgian Congo around the south end of Lake Albert. This has been under investigation for some years, and does not seem to be either spreading or decreasing (Congo Belge 1928, *A.R.*, p. 77). Various endemic centres occur elsewhere in East Africa, notably in Tanganyika, for which an account of plague has been published (Tanganyika 1931).

Various parts of West Africa have had occasional outbreaks of plague, but the disease has not yet attained a strong foothold except, perhaps, in Angola and Senegal. In Angola the first outbreak was in 1921 at Loanda, to which the disease was probably introduced from Lisbon. The epidemic rapidly reached a climax and has steadily decreased, perhaps as a result of intensive campaigns in burning native huts to destroy rats. Up to now there has been no plague on the coast. Since 1932, the South African plague carried by wild rodents has reached Angola, but so far there have been comparatively few cases. It is hoped that the desert conditions in Southern Angola are so unfavourable to rodents that the disease will be kept out of most of the territory (Ribeiro 1936).

Several ports on the Guinea coast have been centres of minor outbreaks, which have occurred in French Guinea, the Ivory Coast, the Gold Coast, and Southern Nigeria; the last being in Nigeria, where, however, there has been no case since 1933. The infection of Senegal from Dakar and Rufisque has been far more severe, but fortunately has kept to a belt of country some 100 km. long by 25 km. wide. The climax was reached in 1924, when some 1,400 people died from plague, but since then the epidemics have been reduced to quite small proportions.

Every port is a potential source of danger, and in this connection special research on rats and their parasites, carried out at the Sir Alfred Jones Laboratory at Freetown, is important. Mr. Davis of the Wellcome Research Institute has been financed by the Royal Society of Medicine to make a census of rats and their fleas in Freetown and the neighbourhood, where the rat-flea index was previously known to be higher than in either Lagos or Accra,

This work has special medical interest, since rats and their fleas are probably responsible for spreading at least two tropical diseases in addition to plague, namely Weil's disease and typhus fever. Of the latter, two cases have recently been diagnosed authoritatively in Freetown, probably its first official occurrence in West Africa.

The flea factor in the spread of plague is a subject which requires investigation. There is evidence to show that the rat-flea population is different in town and country, and this may explain what seems to be low infectivity in certain outbreaks. Dr. Hopkins, Medical Entomologist in Uganda, has published (Symes and Hopkins 1932) preliminary notes on this question.

With regard to preventive and control measures, anti-rat campaigns are carried out in nearly all infected centres, and sometimes have proved successful in small local outbreaks, but they are useful only where every building can be cleared completely. This calls for complete supervision of the type that can be applied in towns, but not in rural areas. The typical native thatched hut provides a favourable home for rats and their fleas, so improved housing in areas of dense population is a primary consideration. The use of poison gas, especially cyano-gas, in native huts has proved effective, and can usually be relied on to kill 75 per cent of the rats; it has the great advantage over the old method of removing the thatch of huts in that it is far less unpopular. Its introduction has therefore led to more complete notification of plague cases. Rat-proofing of granaries and food stores is another important measure; an extensive anti-rat campaign along these lines proved very successful in Kenya in 1936 (Kenya 1936, *D.R.*). Motor-buses give every facility for host distribution. Plague, therefore, like so many other diseases, will succumb eventually only to all-round improvement in hygiene.

Prophylactic vaccination has been made compulsory in some parts of Africa and research on it has been conducted especially by Dr. J. H. Harvey Pirie at the South African Institute for Medical Research. There is still some difference of opinion as to whether vaccines should be made from living or dead cultures. At the Pan-African Conference of 1935 it was concluded that detailed methods of plague control cannot be standardized, especi-

ally in the case of rural areas, where circumstances must determine whether the attack should be primarily against all rodents, domestic or wild, or whether it should involve prophylactic vaccination of humans.

RELAPSING FEVER

This disease may be transmitted by ticks or lice, and is characterized by high fever at regular intervals of about a week. The vectors have been mentioned previously in Chapter X, where references are given to literature. The East African relapsing fever, known also as tick fever, is transmitted by a tick, *Ornithodorus* sp., which frequents native huts and camping sites. It is endemic in certain areas, especially along trade routes, and has sometimes reached epidemic proportions. For example, in Uganda, in prisons in Ankole District, infestation has occurred to such an extent that for a while every non-immune prisoner inevitably acquired the disease. Methods of control depend on eradicating the tick (*see* page 297).

The best known variety of relapsing fever is that of which the vector is the body louse. This disease (League of Nations 1930b) was endemic in French Guinea in 1921, and during the following years spread across equatorial Africa to the Sudan, having a very high case mortality rate among Africans of about 18 per cent, compared with 1 per cent to 5 per cent in Europe. Cases are not now reported, so that the serious views that were taken at one time are to-day not justified.

TYPHUS FEVER

Related to relapsing fever but probably distinct, are the several diseases in the typhus group which cause considerable morbidity and mortality among the Bantu population of South Africa. Much research on these has come from Dr. A. Pijper's private laboratory and a detailed account of the position has been given by Dr. E. H. Cluver (1934). Clinical and pathological investigation over a number of years has shown that there are three distinct typhus-like diseases in South Africa, which are transmitted by ticks, rat-fleas, and lice. Tick-bite fever occurs chiefly in the low-lying region of the Transvaal, but cases are known as far north and

south as Southern Rhodesia and the Cape. Rat-flea typhus, though relatively uncommon among human beings, appears to be enzootic among rats over an extensive area. The reason for this is that, unlike plague infection, the virus of typhus does not kill the rats and hence the rat-fleas do not often overflow on to man. Louse-typhus is much the commonest type, and although milder in South Africa than the classical old-world typhus, some 35,000 cases have been reported during the past thirteen years, resulting in about 4,660 deaths. These figures give a case mortality of 13 per cent, though the actual mortality is certainly much lower, since in a primitive community fatal cases come to the notice of authorities much more frequently than mild ones. Among Europeans in the same period there have been 686 cases with 32 deaths, a case mortality of 4·7 per cent. Louse-typhus has probably been prevalent in South Africa for a very long time, but did not come into prominence until about 1919. From then until 1923 reported cases averaged over 8,000 annually, the worst year being 1920, with 11,000. After 1924 the number fell below 2,000 until 1933, since when it had increased to nearly 7,000 in 1935. The endemic area is now roughly triangular in shape, embracing about one half of the Union, including the Transkei, Ciskei, and the Orange Free State. The recent increase in the disease is in some measure due to its spread in the interior in a north-westerly direction, but the economic distress of recent years has probably been still more important in that the standard of living has been reduced and the body louse has become more prevalent. Typhus will eventually disappear from South Africa, as it has done in Europe, with advancing civilization and an increased standard of living, but meanwhile direct preventive measures against lice succeed in arresting, but not eradicating the disease. The detailed work of Pijper and Dau summarized (1935) the immunological relationship of the three typhus-like diseases as follows: the rat-flea virus immunizes against tick-bite fever, but not against louse-typhus; tick-bite fever does not immunize against rat-flea typhus, but louse-typhus immunizes against rat-flea typhus.

The possibility of typhus fever being present elsewhere in Africa to a greater extent than supposed is a matter for examination. This is suggested particularly by the evidence of Tonking (1932)

in Kenya, and Hennessey (1934) in Uganda, where a definite outbreak of louse-borne typhus occurred in Kigezi. In that district, the inhabitants wear sheep or goat skins with the wool or hair turned towards the body. The incidence of tick-borne typhus in Kenya has been gradually increasing since it was first recognized in 1924. The severity of the disease also seems to be increasing. Two cases of the tick-borne type have been reported from Uganda, but the louse-borne disease has almost died out as a result of the new disinfestor introduced for village use by Mr. Carnie. It is probable that the louse-borne type exists in the Belgian Congo, as it was from there that the disease first reached Uganda.

TUBERCULOSIS

Africa appears to have been free from tuberculosis before the coming of the white man, but the disease is now distributed over much of the continent and seems to be increasing its range. Among Africans, especially those who have not been in contact with the disease before, it takes on a much more virulent form than among Europeans, and the mortality is high. This was first shown in a striking way during the War. Senegalese troops taken to France came from an isolated community which had never been in contact with the disease. In France they were soon infected and the disease passed rapidly through its various stages. Only after the early stages were systematically tracked by frequent examinations was some check put on the waste of life. There is little doubt that the survivors who returned to Africa spread the disease amongst the indigenous population, but it is significant that centres of infection do not seem to have been set up in rural areas, since the known centres to-day are always in towns, where the European element in the population is strongest and the living conditions of natives are particularly bad.

There are now many foci of tuberculosis all over the continent, the mining areas being the most important. Natives migrate into the infective areas for work and return to spread the disease among their own tribes, but in spite of these apparently favourable conditions for dissemination, tuberculosis has not yet become one of the major diseases. Some workers have attributed this to the fortunate lack of bovine infection, but, though this must militate

against the spread of non-pulmonary tuberculosis, it cannot affect more serious forms of the disease. Moreover, as mentioned in Chapter XIV, veterinary research in recent years has demonstrated that tuberculosis is present in certain types of cattle, especially in Uganda and the French Sudan. Professor S. Lyle Cummins, the leading authority in this country on the subject, holds the view that conditions among rural Africans are not really favourable for the disease. Infected cases arriving from elsewhere tend to die soon and cease to be infective foci. In most parts of Central Africa where timber is plentiful, huts are burnt and rebuilt after the death of an inhabitant. The sun too, plays a valuable part as disinfector, and the comparatively easy life, away from the stress of industrial civilization, allows early infection to slumber without progressing to activity, just as it does in Europe between the ages of three and ten.

Where much contact with Europeans has taken place, however, and especially where industrial life and mining development have been introduced, conditions are very different. Soon after the War the problem became serious and a committee of experts was appointed by the Health Section of the League of Nations to ascertain the position of tuberculosis, together with that of sleeping sickness, in all tropical Africa. The two reports (League of Nations 1924 and 1925) summarize the situation up to 1925 and refer to all published literature.

In South Africa the disease among mine labourers soon attained serious proportions, and in 1925 a tuberculosis research committee was formed. The committee, under the chairmanship of Sir Spencer Lister, Director of the South African Institute for Medical Research, included a number of the leading medical men in South Africa and had as adviser and consultant Professor Lyle Cummins, who made an extensive tour in South Africa, working with the committee, and was responsible for a large part of the report (South African Institute for Medical Research 1932), a most valuable volume running to over 400 pages. Since tuberculosis is one of those diseases which must be tackled by education in hygiene, large sections of the report are devoted to the conditions of life in the native territories as well as on the mines, to native custom in relation to disease, and the health services available. It

is pointed out that many hygienic native customs, which are most valuable in preventing the spread of disease, are disintegrating under the spread of civilization. Hut tax, for instance, tends to reduce the number of huts occupied by a family, and hence affects the isolated mode of life mentioned above. It also reduces the practice adopted by many tribes of erecting a separate hut for the isolation of a sick person. The scarcity of timber in many areas is assisting this same effect, and huts in which a death has taken place are now often reinhabited instead of being burnt.

Tuberculosis has also been investigated recently in Tanganyika, the Sudan, and Zanzibar. Dr. C. Wilcocks (Lyle Cummins 1935), a member of the Tanganyika medical service, is conducting research into the disease by survey work in that territory under the auspices of the Colonial Development Fund. Captain S. M. Burrows and Dr. R. J. Matthews, as Dorothy Temple Cross Medical Fellows, have prepared reports on the Sudan and Zanzibar respectively (Lyle Cummins 1935). Professor Lyle Cummins compares their conclusions with those of the South African work, which they bear out and enlarge in a remarkable way. He points out that the actual distribution of tuberculosis has now been worked out by means of intradermal tuberculin tests, among a number of different peoples, including coastal and inland natives in South Africa, inhabitants of Zanzibar, inland natives of Tanganyika (near Moshi), and a section of the isolated Dinka tribe of the Bahr-el-Ghazal. The percentage of positive cases in each community varies from 81 in parts of South Africa to 32·7 in the Dinka. It is clear that while tuberculosis infection is already widely distributed in Africa, its intensity varies directly with the opportunities of outside contact and inversely with tribal isolation. On the whole, the results support the contention that tuberculosis must have been very rare among the African races under their primitive conditions of life, and that it is tending to become widely diffused under the new conditions imposed by the penetration of European civilization and industry into native communities. In East Africa, the penetration of Eastern civilization also plays its part, as pointed out by Spearman (1933), and in this connection, Dr. B. O. Wilkins is at present studying the incidence of tuberculosis among the Asiatic inhabitants of Dar-es-Salaam.

The question arises whether the spread of infection may be expected to be followed by its own antidote in the form of a gradual increase of resistance against the disease. There is some hope that this resistance may be developed, but the general conclusion is that the African appears to be relatively deficient in the power to develop against our European tubercle bacillus the localizing barriers of cellular tissue and fibrosis which work for spontaneous cure in persons of European stock (Lyle Cummins 1935). The excessive incidence and death rate among the negro population of the United States, as compared with the whites, may also suggest a biological dissimilarity in the average response to infection between the black and white races. Against this, however, it may be pointed out that the Red Indians of North America do take on, after a certain number of years, the same reaction to infection as white people, and there are now, in Canada, tribes enjoying almost the same resistance as the whites. It is possible that the negroes of the United States of America and even of Africa would similarly develop resistance if they came to have the same living conditions as the white races. This latter view is supported by experience in the Belgian Congo, where the Government has made efforts to stop the spread of tuberculosis by methods of isolation. By a law on the 10th October 1931, it was ruled that every non-native person suffering from tuberculosis of either kind must leave the country, and that every native patient must be isolated in a hospital. Experience, especially of the FOREAMI doctors, is that the latter measure has had most beneficial effects and that individual resistance is increasing.

Research on tuberculosis among the native population in Uganda carried out by Dr. Carmichael, the assistant veterinary pathologist, has shown that most infections are with the human and not with the bovine type of bacillus (Uganda 1935, *D.R.*).

Since 1913 valuable work has proceeded in Algeria and Morocco, the Cameroons, Senegal, and the Congo. In particular, inquiries into tuberculin sensitivity, etc., initiated in the French African colonies in 1912 by Professor Calmette, constitute a great body of knowledge which has continued to bear fruit ever since. In spite of these researches, however, tuberculosis in the towns of French West Africa is said to be increasing. Prophylactic treatment,

organized by hospital visitors in the homes of Africans, has proved ineffective in view of the insanitary mode of life. Accordingly, it has been concluded that the isolation of patients is indispensable and special tuberculosis hospitals are being established.

Hospital records provide another source of information, and sometimes significant results can be deduced from them; for example, in the Gold Coast there is some evidence that tuberculosis has increased recently, and that nearly every case which enters hospital proves fatal. The case-mortality rate of tuberculosis is, in fact, very high throughout Africa, because patients do not come for treatment until the disease has reached an advanced stage, a fact which emphasizes the need for health visiting in towns.

LEPROSY

In contrast to the tubercle bacillus which has found a home among Africans only during the last thirty years or so, the leprosy bacillus (*Mycobacterium leprae*) has been with them since time immemorial, and some maintain that the real home of leprosy was Africa, whence it has been transported all over the world.

W. H. Hoffman (1932) points out that the northern belt of Central Africa, from Nigeria to Abyssinia, is the most affected portion of the globe. From the Ivory Coast the disease has been reported in from 5 per cent to 6 per cent of the population, and from limited parts of the Belgian Congo even in 12 per cent. About half a million cases of leprosy are already known in Africa, so the real number cannot be less than a million. Leprosy is a house-to-house disease, and the infection of whole families by everyday contact is not by any means rare. There is evidence from good observers that there has been an increase of leprosy in some places in recent years. Hoffman considers that the segregation of sufferers from the disease in isolated colonies cannot attack seriously its endemicity in Africa, because it is easily propagated by sufferers who do not show visible signs, and frequently the most infective cases cannot be selected for segregation.

Until the last thirty years leprosy has been regarded as an incurable disease, but research has shown that the majority of cases in early stages can be arrested and even cured, given adequate treatment; advanced cases, though they may be improved, are usually

intractable. Chaulmoogra oil, which has been used in India from the earliest times, and its derivatives, are the principal drugs; ethyl esters have been used, especially in South Africa with beneficial results, and gold preparations are valuable in leprous affections of the eyes, so that the dreaded blindness of leprosy can in many cases be prevented or alleviated by treatment in the early stages. All authorities are agreed, however, that the improvement of hygiene is the essential method for the eradication of this disease. It has even been found that cases in a settlement have been arrested spontaneously without any treatment whatsoever as a result of the better conditions of life.

The *British Empire Leprosy Relief Association* has established centres for treatment throughout the Empire. This body exists to undertake and assist research, to assist treatment work, and carry out propaganda. Its funds are largely derived from private sources, and are distributed to most of the British territories in Africa, particularly Uganda and Nigeria. The association deprecates the compulsory segregation of lepers except in special circumstances, but encourages by means of propaganda and grants the voluntary segregation of infected cases and emphasizes the necessity of active measures against childhood infection. It is found that limited funds produce best results when devoted to special investigation and to adequately organized treatment and preventive work among the general population. Dr. Cochrane, formerly medical secretary of the association, has carried out an extensive survey of the disease in Ceylon, and considers that similar work is urgently needed in Africa. It is, however, beset with great difficulties, since the type of infection rather than the severity of lesions is important.

Another recent development is due to the Rev. P. B. Clayton. A Committee of the British Empire Leprosy Relief Association and Toc H has been set up, and sufficient funds gathered to train and support for five years in Africa a number of volunteers. Five men, later increased to seven, have been working in Nigeria since 1935 in close association with the medical department (Nigeria 1935, *D.R.*).

The value of segregating infectious cases is obvious, and organization to this end has been the principal measure taken against

leprosy up till now. There are examples in various parts of the world where the disease has been completely eradicated from endemic centres by this means. In Africa legislation regarding leprosy varies from territory to territory; compulsory isolation is not universal. It is obvious that compulsory isolation may defeat its own ends if it has the effect of making natives hide cases which may be infectious.

In South Africa there are five principal institutions for leprosy, containing a total in 1937 of 2,270 persons, of whom 98 were Europeans, 97 coloured, 6 Asiatic, and the rest natives. In addition there were 4,176 certified cases remaining in their own homes (Union of South Africa 1936–7, *D.R.*). Southern Rhodesia has two Government leprosy hospitals at N'gomahuru and Mtoko, and there is a leprosy section attached to the Mnene Medical Mission, which is subsidized by the Government. The patients live a practically normal life on large estates, and it is encouraging to note that more and more cases are seeking admission; the total increased from 508 in 1929 to 1,315 in 1936. The work has been furthered by grants from the British Empire Leprosy Relief Association (Southern Rhodesia 1936, *D.R.*).

In British East Africa numerous well-organized leper villages exist, mostly under the direction of missions, and aiming at maintaining the patients under conditions as natural as possible. In addition, treatment centres are becoming established in many areas, thus in Nyasaland there are twelve clinics all administered by missions, and receiving grants from Government in proportion to the number of cases treated. The Tanganyika Government controls settlements at Dar-es-Salaam, Moshi, and Mkalama, and treatment centres at the medical stations, together with numerous settlements throughout the country. Assistance is given to mission settlements, among which those of the Benedictine Mission at Ndanda and Peramiho in the Southern Provinces are prominent. The number of segregated cases in 1936 was about 3,400 (Tanganyika 1936, *D.R.*).

In Uganda a survey was carried out in 1930–1 to determine the extent of the disease. The incidence was found to range from 0·05 per cent of the population in Entebbe district to 1·26 per cent in Lango district, so leprosy in that country could hardly be

regarded as a disease of great importance. Since then there is no reason to believe that any marked change in the incidence has come about. There are three old-established colonies run by missions, on an island in Lake Bunyoni in Kigezi district, at Nyenga in Mengo, and at Kumi in Teso. A new colony was started at Buluba by the Mill Hill Mission in 1934, run in association with that at Nyenga. Recently the Native Administration has taken over the control of the settlement, and the mission activities are restricted to treatment at the dispensary. At each centre the patients, who come voluntarily, are supported by maintenance grants for the first year until they have established their own farms and become self-supporting. In conjunction with the colonies, homes have been established for uninfected children who are segregated from their parents as early as possible. In Nigeria and the Gold Coast, where leprosy is said to be particularly virulent, special government organizations are established and much work is being carried out by medical missions assisted by grants from the central Government, the Native Administrations, and the Leprosy Relief Association. In Sierra Leone a survey of cases recently completed shows a total of 3,675, representing about 1 per cent of the population.

In the French colonies a prophylactic campaign against leprosy was started a few years ago, and is run in conjunction with the large leprosy hospital, settlement, and laboratories near Bamako (*see* Chapter XV). Emphasis has been placed on research, and a notable discovery is that certain plants, *Caloncobas*, growing especially in the Ivory Coast and the Cameroons, yield extracts which have effects on leprosy similar to the products of chaulmoogra.

In the Belgian Congo the legislation of 1931 provides for leper segregation. In some areas the disease is particularly common, especially in Uélé-Nepoko, where Professor Dubois (1932) made a survey in 1930 and found in some parts as much as 12 per cent of the population suffering. His report stimulated the Croix Rouge du Congo to start a campaign with financial assistance from the FOREAMI, the *Institut de Médecine Tropicale* and the Ministry for Colonies. A model village was built at Pawa, and sufferers from the disease were persuaded, with plenty of food and good housing, to live there. There are now three such villages in

Uélé, where the inhabitants grow their own food and are practically self-supporting. A laboratory has been erected at Pawa for leprosy research and was opened in 1934 with Professor Dubois as director. In the Bas Congo, where leprosy is relatively rare, the FOREAMI have adopted voluntary segregation. Some 500 patients, representing about 20 per cent of the total cases, now live in fourteen settlements, and the rest are treated regularly in their homes.

With regard to drugs, chaulmoogra oil forms the basis of nearly all treatment drugs; it is derived mainly from the seeds of two species of the *Hydnocarpus* tree growing wild in Western India and Siam. The oil is very cheap in India, so the cost in Africa is largely that of transport. With a view to producing supplies locally, *Hydnocarpus* trees are being tried with varying success in a number of African territories.

HELMINTHIASIS

In this category come infestations by a multitude of parasitic worms, which are very prevalent in Africa. The commonest are the Nematode worms, *Ancylostoma* (hookworm), *Strongyloides, Trichinella*, various kinds of *Filaria* and *Ascaris*, the Trematode *Schistosoma* (*Bilharzia*), and several tapeworms in the Cestode group. Helminthiasis as a whole is regarded as of very great importance in many African territories; in East Africa it has been estimated that over 90 per cent of the population are infected with one or more kinds of helminth, and frequently as many as six kinds have been found in the same individual.

Fundamental research has revealed the life histories and some of the pathological effects of the different helminths, a work in which Professor R. T. Leiper's Department at the London School of Hygiene and Tropical Medicine has been prominent. Some cause definite disease showing specific effects: for example hookworm produces anaemia and general lowering of vitality; schistosomiasis produces impairment of the functions of the liver and other organs, and in serious cases death from toxaemia and complications caused by the damaged organs; the cysticercus stage of certain tapeworms, situated in the brain, is undoubtedly the cause of a kind of epilepsy; and there is some evidence that helminth toxins

may produce cirrhosis of the liver, a certain degree of which is common amongst natives in East and Central Africa. With these and a few other exceptions, the results of mass infestation by helminths are little known, but there can be no doubt that the general physical and mental activity of heavily infected persons must be impaired.

The relation of helminthiasis to nutrition is a question calling for examination. It is clear from experience in many parts of the world that certain parasitic worms flourish chiefly in subjects who are weakened in other ways, perhaps by insufficient or unbalanced diet (*see* pages 563 and 576). But in the African population heavy infestation may be a cause of malnutrition rather than an effect. There are several important worm infestations which are definitely known to be uninfluenced by the malnutrition of their hosts. In certain cases feeding habits may have direct effect in causing infection, particularly in the case of peoples who eat raw meat and those who enrich their supply of mineral salts by eating earths, etc., from special areas (*see* page 578).

To indicate the severity of infection in different territories the following notes have been taken from recent medical reports. In Southern Rhodesia schistosomiasis is the most important helminth disease, with hookworm taking a second place. Schistosomiasis surveys have been carried out in this territory as well as in the Union of South Africa and indicate that the incidence varies widely in different districts. Among the native population it reaches 50 per cent in certain areas and even for European children, figures as high as 36 per cent have been recorded in Southern Rhodesia. In the Union propaganda led to the sanitary protection of bathing places, and treatment campaigns have been organized by the Transvaal Bilharzia committee in co-operation with school medical officers. In Northern Rhodesia it has been found that 31 per cent of workmen recruited by the Rhokana Corporation are infected with hookworm. Helminth diseases are common in Nyasaland, 140 out of 1,494 cases at the Zomba Native Hospital were admitted on account of hookworm, and 47·2 per cent of all other cases were infected with these helminths. In one village in Kuweraza district 100 per cent of the people examined gave positive reactions. That drainage may play an important part in

determining the incidence is proved by the returns from mountainous and well-drained places such as Mlanje and Zomba, which show 22·2 per cent to 28·3 per cent of hookworm infestation compared with 53 per cent and 64 per cent in Port Herald and Karonga, which are both low lying and poorly drained. In Northern Nyasaland a heavy child mortality was traced to intestinal infection by worms resulting in cirrhosis of the liver. In Tanganyika helminths account for 19 per cent of all diseases and 34 per cent of all deaths at Government institutions. In Kenya perhaps the most complete data on hookworm infestation ever recorded among a backward people were obtained during the campaign in the Digo District in 1927–8. Preliminary examination indicated that every individual was parasitized, so treatment with anti-helminthic drugs, carbon tetrachloride and oil of chenopodium, was applied indiscriminately. As a proof of the wholesale parasitization one village was selected, being apparently healthier than most, and was subjected to detailed study at a time of year, at the end of the dry season, when infection should have been at its lowest. H. D. Tonking (1935) records the results: every individual was infected and the average number of hookworm eggs was 466 per cubic centimetre of faeces.

The remedial measures against helminthiasis, especially hookworm, depend largely on improved sanitation and general standards of living, and above all the establishment of latrines in every village. It is clear that extensive treatment campaigns can be of little permanent value until steps are taken against reinfestation. Accordingly, a two-stage policy is generally adopted in most territories, consisting firstly of propaganda for the establishment of latrines and secondly of efforts to reduce infection by treatment. Practically the whole of rural Africa is still in the first stage.

TYPHOID FEVER

Typhoid, para-typhoid, and the associated diseases are undoubtedly prevalent in most parts of Africa. According to hospital returns, Africans do not appear to suffer from them to the same extent as Europeans, but authorities in the Belgian Congo do not subscribe to this opinion, since severe epidemics of typhoid have been known, especially in Katanga and the Bas Congo. Diagnosis

is by no means satisfactory on account of irregular symptoms, so the incidence is almost certainly higher than is popularly supposed. Inoculation against these diseases has reduced much of the risk to Europeans living in unhealthy areas; for example, the adoption of general inoculation of Europeans in the Belgian Congo has reduced the cases from 38 in 1928 to only 3 in 1934. Experience in temperate countries indicates that it is unlikely that the typical group of diseases will disappear from the tropics until the standard of sanitation has been raised to that which now exists in the large towns in civilized Europe.

YAWS AND VENEREAL DISEASES

The difficulty of distinguishing between infections from yaws and syphilis in native patients causes trouble in estimating the prevalence of these diseases, but throughout Africa there is no doubt that the spirochaetal diseases must be regarded as of far greater importance than the more obvious diseases already discussed, with the exception perhaps of malaria and sleeping sickness. Practically all estimates of incidence are based on attendances at hospitals and clinics, and therefore give a poor idea of these diseases in rural areas. A few general estimates, however, have been put forward; thus in East Africa the incidence of yaws and syphilis together was put, until quite recently, at some 60 per cent of the population, but the treatment campaign of recent years has probably reduced this considerably. In Tanganyika the proportion of yaws and syphilis together to other parasitic diseases was 57 per cent in 1929, but had dropped to 37 per cent in 1933. In 1936, the cases treated at Government institutions were syphilis, 23,484; yaws, 70,682, and gonorrhoea, 9,619. Compared with these, in Uganda the figures were syphilis, 63,695; yaws, 62,240; gonorrhoea, 14,101. The history of venereal diseases in East Africa is somewhat obscure, but it is fairly clear that syphilis has been established there much the longest, since it probably arrived with the Arabs and was prevalent long before the European occupation.

In West Africa, where in general gonorrhoea is the more important in southern territories and syphilis and yaws in the northern areas, rough estimates of incidence range from 50 per cent to 90

per cent of the population. In Nigeria steady advance has been made in the treatment of yaws and although usually this cannot be sufficiently prolonged to produce cure, the incidence of florid yaws has decreased greatly. Little progress has been made in the elimination of syphilis, which is rampant. Cases treated during 1936 were:

	Government hospitals and dispensaries	*Native Administration dispensaries*
Yaws	110,588	83,346
Syphilis	18,432	32,671
Gonorrhoea ..	16,386	20,839

The symptoms of yaws are generally quickly removed by a few injections. This fact is of much value to the medical worker in gaining the confidence of natives, but it complicates the treatment of other diseases, since natives demand the needle for the cure of every complaint and are disappointed when it is refused. On the other hand they consider a cure is effected when obvious symptoms disappear, hence for the venereal diseases they seldom come for treatment long enough to obtain a complete cure.

An answer to the question whether yaws and syphilis are in fact one or two diseases is urgently required. At present, there is no simple laboratory test to differentiate the two, since all known reactions for syphilis are the same as for yaws. J. A. Carman (1935), Hewer (1934), and G. Mattlet (1933) have discussed this question at some length. Doubt also exists whether yaws can produce lesions of the brain and spinal cord as does syphilis, a subject discussed by H. L. Gordon (1934a and b). Furthermore, it has been suggested that yaws and syphilis are so closely related that one may confer immunity against the other, and hence it may be inadvisable to complete the cure for yaws in that the patient may thereby become susceptible to syphilis. This is discussed by P. D. Connolly (1931). There can, however, be no dispute that treatment which clears up cutaneous lesions does in fact lead to a reduction of incidence in the disease in the next generation,

although treatment may not be continued long enough to effect a complete cure of the infected of this generation.

Gonorrhoea has proved particularly difficult to combat owing to the need for long courses of treatment. Native women are very unwilling to submit themselves to treatment, and many complications are due to neglect. Short-wave diathermy may prove useful in reducing the time necessary for effective treatment. Much good work has been done in townships by venereal disease clinics, but ignorance of the distribution of the several diseases involved is such that the whole question calls for serious study. Perhaps the most complete system for treatment has been adopted in parts of the French colonies. At Fort Lamy, for example, where the incidence of syphilis is put at 80 per cent of the population, every patient is given a numbered metal disc which is presented at each attendance, so that his past record can be looked up without difficulty. Statistical data are thus slowly accumulating.

In the Belgian Congo persons suffering from syphilis or yaws are obliged to present themselves at clinics at regular intervals so long as any sign of the infection remains. Records are also kept of the medical history of women believed, or suspected, to be syphilitic.

OTHER DISEASES

A number of other diseases, some recently introduced, remain to be mentioned. Of these, *pneumonia* is one of the most frequent killing diseases, as shown by clinical records at hospitals. It is especially prevalent where there is a strong contrast in the seasons, as in the Guinea lands where the onset of the cold harmattan is regularly followed by a flood of hospital cases. Moreover, in areas where development of labour has taken place, particularly on mines, pneumonia is becoming of increasing importance. Recent work in South Africa (Lister and Ordman 1935) and in Kenya has thrown much light on the epidemiology and type incidence, and the report of the South African Institute of Medical Research for 1935 also records that the use of a mixed vaccine for the prevention of pneumonia among native miners on the Rand is giving encouraging results.

Efforts are being made to control *smallpox* by vaccination, and it is reported that native opposition is tending to decrease. *Influ-*

enza frequently makes its appearance in epidemic form, affecting Europeans and Africans alike. *Measles*, which has probably been introduced recently, sometimes produces very serious symptoms among the African population, who seem to have less immunity than Europeans. Thus epidemics in South Africa and the mining areas of Rhodesia have been a cause of alarm in recent years. *Dysentery*, both amoebic and bacterial, is still a cause of considerable mortality. *Malignant diseases* exist, but it is impossible to draw any conclusions as to their prevalence from the cases reported in statistical returns; indeed, as native confidence in European surgery increases, it is even possible that cases treated may actually increase, but in this connexion, as with other diseases, actual prevalence among the African population cannot be estimated. The study of these diseases has been advanced in a series of publications by the pathologists of Nigeria, particularly by E. C. Smith and B. G. T. Elmes (1934).

CHAPTER XVII

HEALTH AND POPULATION

INTRODUCTION

THE first section of this chapter is devoted to a sketch of some of the work in collecting vital records which gives a real foundation for knowledge of the state of health of the population. This leads on to a discussion of ways in which health may be improved in the rural areas as opposed to the towns, where in most cases adequate hospitals exist. Finally considerable space is devoted to the food and nutrition of Africans in view of the increasing interest in the probability that malnutrition may be a cause of widespread ill-health.

VITAL STATISTICS AND DEMOGRAPHY

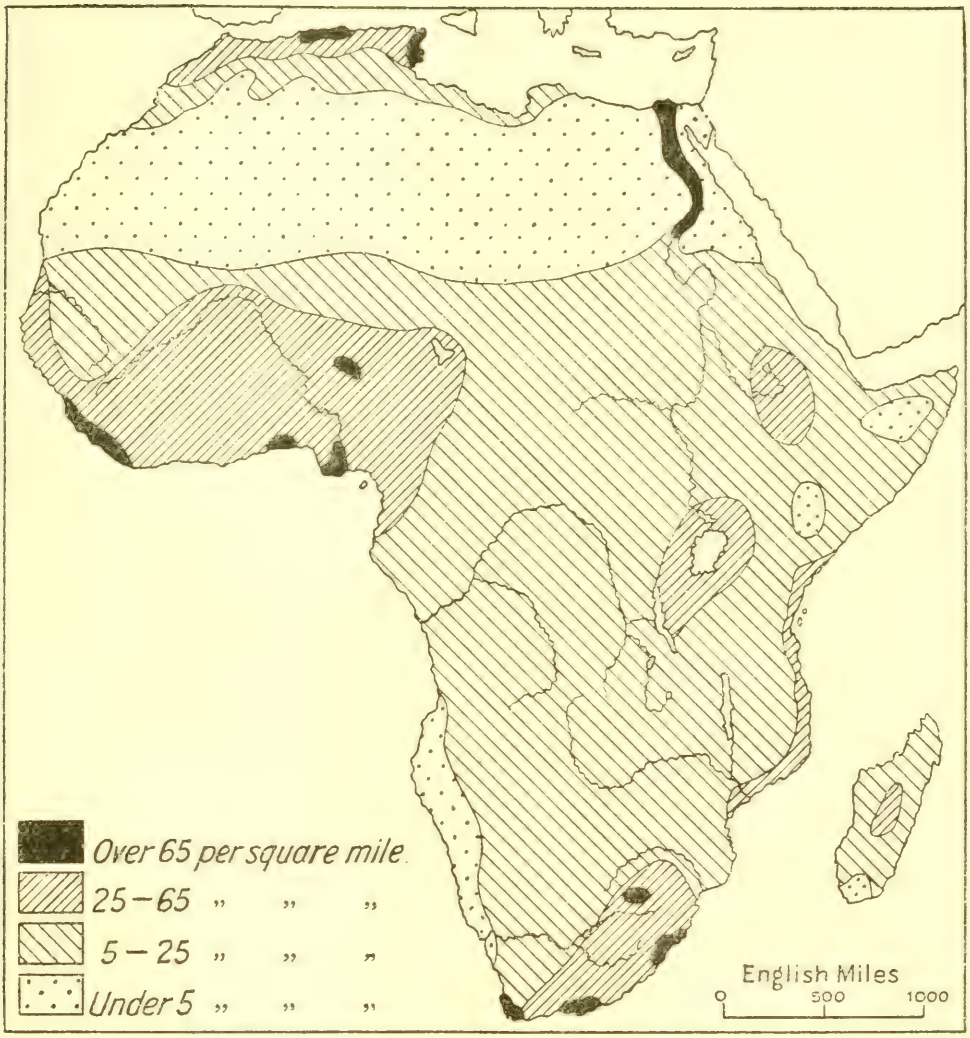
It is perhaps unnecessary to emphasize the extreme importance of demographic data. P. G. Edge (1932) compares the collection and accurate recording of vital statistics with commercial book-keeping, without which no enterprise can hope to succeed. The same author (1932 and 1937), and every one else who has been connected with the collection of demographic data from African populations, stress the difficulty attached to such work among people who do not yet understand and may still be prejudiced against the methods of the white man.

Chapter IV of *An African Survey* has outlined and discussed the existing agencies for collecting population records in Africa, and Dr. Kuczynski (1936) has considered these from the point of view of population trends, so it is only necessary here to summarize such data as bear directly on medicine and health. These data consist firstly of general censuses of the population which have

usually been carried out in British territories at ten-year intervals, and in French every five years. Secondly there are the systems established in certain localities, of registering vital events such as births, deaths, and marriages. Thirdly, certain special studies have been made for defined areas giving much fuller data on the prevalence of diseases and general health conditions of samples of the population.

In the Union of South Africa the first simultaneous census of all the provinces took place in 1904, and subsequently in 1911, 1921, and 1931. On the last occasion financial stringency reduced its scope to a census of Europeans only, with little more than estimates for other categories of the population, but in May 1936 an additional complete census was made. This showed a material increase for all categories of the population from 1921 to 1936, but it was not considered that all the figures could be accepted with confidence. Censuses for the South African protectorates were made in 1911, 1921, 1931, and 1936. In Southern Rhodesia censuses, started in 1901, have taken place more frequently, in 1904, 1907, 1911, 1921, 1926, 1931, and 1936, the last mentioned being simultaneous with that in the Union. Figures for native population are only estimated, being based on the number of tax-payers multiplied by a selected figure, usually $3\frac{1}{2}$ or 4.

In most of the colonial territories a regular decennial census has been made. In Northern Rhodesia, in 1911, 1921, and 1931, the European, Asiatic, and coloured races were actually counted, while the Africans were estimated in a similar way to that used in Southern Rhodesia. In both the Rhodesias special returns were made from the employers of labour on mines. In Nyasaland, censuses have been more comprehensive and more accurate than in many other territories. In that of 1911 all non-natives were enumerated, but the estimate of native population was based on the number of hut taxes paid, multiplied by 2·8, a figure reached by counts in selected villages. The more recent censuses of 1921, 1926, and 1931 involved a considerable staff of enumerators, and the records on the day of census were preceded by three weeks of work by the enumerators to serve as a check on the final figures. This is a system used in India and elsewhere (*see* P. G. Edge 1932, p. 19). In 1931 the population figures were supplemented by



Map 3. Density of Population.
(*Reproduced by permission from 'Africa'. Fitzgerald, 1934.*)

data on literacy and infirmities, the latter being divided into blindness, deaf-mutism, and total infirmity. In Tanganyika a census was made by the German administration in 1913 and by the British in 1921, 1928, and 1931. The responsibility for these lay mainly with the native administrations, but the figures were checked by enumerations of selected villages carried out by the district officers. A division was made into children and adults, the line being drawn at puberty rather than at a definite age. In the results it was assumed that a high proportion of children is a sign of a growing population and suggests a correlation with satisfactory health conditions, particularly diet, since the highest percentage was found among tribes practising both agriculture and animal husbandry. In Kenya no complete census has yet been made of native races. Except for Europeans, the only areas where all races were actually enumerated in 1931 were Nairobi and Mombasa, the figures being supplemented by returns of natives resident on European farms. The native population of nearly 3,000,000 is estimated annually by the chief native commissioner on the basis of counts made for hut and poll-tax: married men, single men, women, and children are shown separately, but the counts of men, old women, and children are said to be definitely inaccurate, the last being sometimes estimated as a percentage, say 37 per cent of the total population. The Kenya Land Commission (Kenya 1934) concluded that the native population as a whole is increasing rapidly and will do so during the next twenty years. The censuses of Uganda were made in 1911, 1921, and 1931. For that of 1931 the whole protectorate was divided into the smallest recognized administrative units, and information for each member was asked on tribe, sex, age, civil condition, occupation, and infirmities. There were five age-classes recognized, under one year, one to seven, seven to eighteen, poll-tax payers, and aged persons. There is little doubt that the data are more correct than for most other territories, but it seems that the demand on the native enumerators was so great that many inaccuracies crept in.

In Nigeria a decennial census has been made in Lagos since 1871 and for the whole country in 1911, consisting of a rough enumeration, in 1921, when population figures were accompanied by data on native customs, and in 1931. In that of 1931

a general census was carried out in the Northern Provinces with an intensive census in six districts of Katsina Emirate and a number of selected villages elsewhere. For the general census data were given for age, sex, occupation, and religion, while the intensive census included also birthplace, infirmities, fertility, numbers of livestock, amount of cultivated or uncultivated land, and yield of crops. In the Southern Provinces unsettled political conditions made a complete census impossible and the figures were based only on compiled estimates. The degree of accuracy of these various censuses was estimated as follows: the probable error was found to range from 2 per cent in the intensive census of the Northern Provinces to 10 per cent in most of the Colony and Southern Provinces, while in the provinces of Onitsha, Owerri, and Calabar the error was up to 15 or 20 per cent. The Gold Coast has had a decennial census since 1891 though the first two were confined to the Colony. It was not till 1931 that educated enumerators were used throughout. In the rural areas data include tribe, colony of origin, infirmity, standard of education (below or above Standard IV), and age in three groups, under fifteen years, fifteen to forty-five, and over forty-five. For the large towns occupation was added to these data and age was further divided into less than one year, one to five, and five to fifteen. The results have been fully analysed by A. W. Cardinall (1932). Sierra Leone has had a decennial census in the Colony since 1881 and in the Protectorate since 1901. In 1931 a complete enumeration was made for non-natives, but Africans were still being estimated by the administrative officers after detailed counts in selected villages.

In the French colonies a five-yearly census has been made throughout the present century, in which French citizens representing about 2 per cent of the total population are enumerated. For the rest estimates have been based on tax registers and accuracy is not claimed (A.O.F. 1935). There are no data on age-classes, etc. In 1933 a scheme was put forward for French West Africa by the Governor-General for an enlargement of staff to obtain a proper census within five or six years, but no such steps have been taken in French Equatorial Africa. French Togoland and Cameroons have similar five-yearly censuses, but

for the latter there seems to have been serious disparity between censuses made in 1924 (2,771,132 persons), 1926 (1,877,113), and 1931 (2,223,802). In parts of the Cameroons a card index record of every individual, similar to that of the Belgian Congo, has been started.

In the Belgian Congo the anxiety felt in recent years as to the alleged decline of the African population has given a stimulus to much census work. The system adopted has been to establish a register in the form of a card index at the headquarters of each administrative division, with a card for every individual. The cards are checked during annual visits, and by 1935 the system was said to cover 91 per cent of the adult males in the Congo. The Governor-General, Monsieur Ryckmans (1933) points out that it has not been possible yet to cover every district in the Congo or to maintain the records up to date, so a check has been introduced in the form of accurate counts each year in sample areas. By 1936 it was estimated that about one-sixteenth of the total population was covered in this way.

Systems of registration of vital events are at present reasonably complete for Europeans, and in most countries for other non-native races. For Africans, however, data are available only for a small proportion of the population living mainly in urban areas. In South Africa the registration of births and deaths has been compulsory for all races in urban areas since 1923 and for Europeans, Asiatics, and coloured races in the rural areas. Even in the urban areas, however, accuracy is very doubtful in regard to Africans in view of the large proportion of temporary residents. In Southern Rhodesia it is stated that reliable vital statistics of Africans are quite unobtainable at present. Northern Rhodesia has instituted a registration of births, deaths, and marriages in some 411 villages with 43,000 inhabitants, representing about 3 per cent of the total population; the efficiency of the system is said, however, to be doubtful. Similarly in Nyasaland there is compulsory registration in Fort Manning District with 35,000 inhabitants, or 2 per cent of the population. In Tanganyika all registration of races other than Europeans is optional, while in Kenya there is no such system at all, even in Nairobi and Mombasa. Uganda has introduced voluntary registration for all provinces.

In the West African dependencies registration is established in many towns: thus in Nigeria it is compulsory in Lagos, Calabar, Kano, and Port Harcourt, covering in all about 1 per cent of the total population. The Gold Coast is better provided with compulsory registration in thirty-five towns, one of which is in British Togoland. This covers about 8 per cent of the total population, and in the case of all deaths either a certificate or a post mortem examination is required. In Sierra Leone registration is effected in all the colony, covering some 6 per cent of the total population, but is said to be complete only in Freetown, while the Gambia has registration in Bathurst, containing 7 per cent of the population, but the data for births are said to be incomplete. In the French colonies registration is compulsory only for French citizens, but a voluntary system is in existence elsewhere. In the Belgian colonies there is compulsory registration for Europeans, but for natives the only records appear to be by Christian missions, who record baptisms, marriages, and burials.

Data from the systems of vital registration in force are published in annual reports of the medical departments. Each year all such reports are summarized and the data on vital statistics have been arranged in comparative tables by H. H. Scott (1931–5) and P. G. Edge (1936), and in that form published in Supplements to the Tropical Diseases Bulletin. The data selected refer particularly to the birth, death, and infant mortality rates. So many of the figures are based on unreliable and incomplete data, however, that errors are necessarily included as the authors point out, and many sections of the tables have to be left blank.

Special data have been obtained, in limited areas, in connection with medical campaigns, accompanied by the examination of large numbers of persons and complete registration of vital events over a short period. In Tanganyika, for example, such an investigation was carried out by Dr. A. R. Lester in the Kahama area. Its objects were fully set out in the medical and sanitary report for 1927 (Tanganyika 1927, *D.R.*), and may be summarized as an attempt to obtain reliable information and statistics from a typical unit of the native community. The investigation lasted from 1927 to 1931 and dealt with an area of over 7,000 square miles and a population of 76,000 divided among four native

authorities, each with a separate clinic. Unfortunately an unforeseen factor, the spread of sleeping sickness into the district, altered drastically the normal life of the population; during the period of observation many people died of or suffered from the disease, and others were removed from their homes into fly-free areas. Although the value of the investigation was much reduced by this epidemic, the results are of great interest for the study of methods to be employed in such work. They illustrate the limited value of observations made over a short period in view of the high degree to which African population figures are affected by emigration and immigration. To mention a few of the results, during the four years of the study more males were born than females, but the mortality among male children was higher; the average period of married life in the area was 11·9 years before dissolution by separation or death; the average number of living children per woman was 1·5, but there was a high percentage of miscarriages and abortion owing to syphilis; the percentage of women with a syphilitic history was 59·2, but including other venereal diseases and yaws it was 89·3. In addition to these general data, a specific medical survey was made of four villages with a population of 1,910 persons, and Dr. Lester's report contains cultural studies which illustrate the possibilities of this kind of survey.

During the same period another intensive investigation, under Dr. C. R. Phillips, was made in the Digo District of Kenya in connection with the campaign against helminthiasis in that area (*see* page 552). Although the period was too short to produce vital records of real value, many suggestive data have been recorded in the medical department reports (Kenya 1932, *D.R.*, pp. 13–25; 1933, *D.R.*, pp. 17–25, and Phillips 1932). In Kenya also for six months during 1930 and 1931 a rather similar study was made of the Masai to produce data on a typical pastoral tribe. By comparison with the Digo, the Masai showed little malaria and only a small degree of infection with hookworm; but on the other hand the incidence of tapeworm, roundworm, pyorrhœa, and eye affections was high. The mortality of infants and children bordered on 500 per thousand births compared with about 100 or so among the Digo, while some 34 per cent of the Masai women appeared to be sterile owing to gonorrhœa. This

investigation has important bearings on the findings of Sir John Orr and Dr. Gilks concerning the nutrition of Kenya natives, referred to later.

In Nyasaland Dr. T. A. Austin, in 1935, made an intensive study of the isolated population of Chilwa Island in the lake of that name about twenty miles from Zomba. The total population of the island numbers about 700 and very little European influence has been felt. About 30 per cent of this population was subjected to an intensive medical examination, including estimates of urines, stools, the examination of blood films, spleen, and general diseases. The results showed a very high infestation by parasites and diseases somewhat similar to that found in Kenya and Uganda.

In Nigeria a special medical census was carried out in 1931 in connection with the general census, and the reports by Dr. R. C. Jones (1932) of the Northern Provinces and by Dr. J. G. S. Turner (1932) for the Southern Provinces are publications of great importance. For each area special villages or towns were selected in different climatic zones, and in each a thousand or so of the people were examined in full detail on a standardized scheme. In all 9,491 persons were examined in four villages of the Northern Provinces; these villages were approximately on the same line of longitude, but in distinct climatic zones with an annual rainfall ranging from 25 to 40 inches. In the Southern Provinces 11,023 persons were examined in Abeokuta, representing rural conditions, the Cameroons, forest and hill country, and Arogbo, providing swampy conditions in the creek area. The difficulty experienced in obtaining information was considerable, as it has been in all other parts of Africa, but satisfactory returns were obtained for tribe, sex, age, birthplace, occupation, nutrition, stature, general diseases, ulcers, vaccination, etc. Additional information from females over ten years of age included numbers of children alive and dead, still and premature births, pregnancies, miscarriages, multiple births, etc.; and for children under twelve years of age the size of spleen and liver were measured roughly by finger breadths.

In the Belgian Congo, several special sets of data have been collected, but the most important records are those of the large FOREAMI organization (*see* page 499) which has been able

to compare the health conditions of a considerable population in the Bas Congo from year to year since 1931. The results (FOREAMI 1931–5, *A.R.*, Trolli 1934, Trolli and Dupuy 1934) provide what is probably the most detailed piece of demographic work yet undertaken in Africa. The twenty-five doctors employed make medical examinations of some 350,000 individual natives, men, women, and children, every six months. By this means the prevalence and spread or regression of the principal diseases have been established, and full data on such subjects as infant and maternal mortality have been collected. Perhaps the most striking results concern the sex-ratio. In European countries the births of boys exceed those of girls in the proportion of 105 or 106 to 100. Among the Bakongo, however, the ratio is apparently reversed, since there were 93·7 boys to 100 girls born in 1932, 99·1 in 1933, and 99·4 in 1934. This apparent reversal of the biological law that more males are born than females, is attributed by Trolli (1934) to the matriarchal society of the Bakongo, which leads to girls being more sought after than boys. This factor must clearly affect the survival rate of boys, but it is difficult to see how it can affect the birth rate. In the same paper Trolli advances another explanation that the mortality of males is greater before birth and the first few weeks of life. M. P. Ryckmans (1933) now Governor-General of the Congo, suggested that there may have been errors in collecting the data sufficient to account for the abnormality, but Trolli points out that the data were obtained each year by seven censuses by different members of the staff working in separate districts.

During the period from birth to 3 years the female sex still predominates over the male among the Bakongo, but the dominance becomes progressively less until from 3 to 15 years the proportion is reversed and there are more boys than girls, perhaps a result of an emigration of girls. A second reversal of sex-ratio occurs among adults, there being more adult women than men, a result of higher death rate and emigration of men. This difference is exaggerated among old people of 45 years and more, among whom the low figure of about two men to three women is the average. Figures and graphs showing the remarkable change in sex-ratio are published separately for the seven districts of the

area studied, and all bring out the essential facts mentioned above. With the detailed figures collected, the birth, death, and infant mortality rates have been worked out for the several districts under the FOREAMI, in a way which shows clearly where health work is most required.

These observations have now been carried out over a period of several years which makes it possible to estimate changes in the population. The general opinion has been that the native population of the Congo is decreasing and that steps taken by the Government are not sufficient to arrest it; but the figures for the Bas Congo in FOREAMI records show a successive increase as follows: in 1932 the increase was 17·3 per cent, in 1933 21·4 per cent, and in 1934 19·8 per cent, the lower figure for 1934 being due to an epidemic of bacillary dysentery. The conclusion reached is that the population is increasing quite rapidly, largely as a result of medical aid.

In the mandated area of Ruanda-Urundi the Belgian authorities have also undertaken a medical census, particularly with a view to determining infant mortality. By 1935 in Ruanda 1,279,096 people out of a total estimated population of 1,685,283 had been individually registered, and in Urundi 219,856 out of an estimated total of 1,700,300. For the purposes of reckoning infant mortality the areas studied were divided into three groups according to the degree of European influence; these were agriculturists, persons in close proximity to missions or plantations, and Christians. In the most primitive regions the infant mortality rate was calculated to be 100 per thousand, which compares very favourably with many other parts of Africa. The systems of sleeping sickness inspection in the Belgian Congo have also produced useful information, since every individual examined is recorded in regard to sex, age, profession, and medical details.

For the French territories some of the results published in the annual reports on the Cameroons and Togoland to the Mandates Commission fall into the category of special medical studies. For the Cameroons a series of maps and graphs shows the relative importance of principal diseases in different parts of the territory. There are data also for the sex-ratio, which show results rather different from the Belgian work mentioned above. Thus there is

a preponderance of girls from birth to 14 years; this ratio is exaggerated among adults between 14 and 45 years, but is reversed among older people, so that from 45 years upwards there are more men than women. The rate of infant mortality for children up to 3 years is rather high, between 200 and 250 per 1,000. The Togoland annual report for 1934, contains maps indicating sex-ratio and the proportion of children less than 14 years to adults in different parts of the territory. These suggest that the population of about one-quarter of the territory is stationary or regressive, while in the rest it is on the increase. In Togoland also sample surveys have been made by medical officers which give more valuable figures than the general censuses.

Population maps have been constructed for various parts of Africa. Thus S. J. K. Baker (1936) has compiled such a map for British East Africa and Ruanda-Urundi, and concludes that East Africa as a whole has not yet attained its optimum population, though the density of population in some areas is far above the optimum level in relation to the economy and technical knowledge of the tribal groups. For Tanganyika a much more detailed study has been made by C. Gillman (1936), who has produced what is probably the best population map for any part of British Africa. He showed that 62 per cent of the area is practically uninhabited, mainly owing to the absence of water, and that two-thirds of the population is concentrated on a very small proportion of the territory, about one-tenth of the total area, where permanent water exists. This uneven distribution has naturally led to serious exhaustion and erosion of the soil in certain areas, a state of affairs which can only be remedied by redistribution of the population after water-supplies have been made available by tapping underground sources (*see* Chapter III). Another study of population in relation to water-supply was made some years earlier for Nyasaland by F. Dixey (1928).

Regarding changes in Africa's population as a whole, Professor A. M. Carr-Saunders (1936) and Dr. R. Kuczynski (1936) both stress the inadequacy of existing material as a basis for conclusions as to population trends.

RURAL HYGIENE

The relative claims of towns and rural areas for special attention by medical departments and missions have been discussed in Chapter XV, pages 462, etc, and the existing organizations devoted to improving health in rural areas are outlined in pages 471–503. In this section examples are selected to show how far some of the major problems of rural medicine and hygiene are provided for by these agencies. The need for further health services for rural areas in the British colonial territories was emphasized in a series of papers relating to the health and progress of native populations published by the Colonial Office (1931).

The desirable minimum medical and sanitary service for a large rural district has often been discussed, and the definition by Dr. A. R. Paterson (1928b), which has been adopted as the official scheme for the development of services in Kenya, may be given. Paterson considers that there should be at least one district medical officer, one medical officer of health, one dispensary medical officer, two European nursing sisters, one European sanitary inspector to train natives how to make permanent sanitary dwellings, perhaps a European hospital assistant and storekeeper, an adequately trained and disciplined native subordinate staff, a hospital with accommodation for about 100 patients, and from six to twelve out-dispensaries; and, as an essential part of the service, good housing for the staff. This outline represents only a skeleton staff compared with that which will be required to destroy disease and maintain health in a quarter of a million people. Accordingly it is recognized in every territory in Africa that adequate provision depends on the employment of trained African personnel, a question discussed in Chapter XV.

The Pan-African Health Conferences of 1932 and 1935 (League of Nations 1933b and 1936) gave special attention to the question of hygiene and medical services in rural Africa. From the several reports and resolutions adopted at these conferences, the following general principles emerge:

1. In countries with a large backward population the preventive and curative functions cannot be separated in field personnel. In urbanized areas and some well-advanced rural areas, where

natives appreciate the value of doctors, it is possible to separate the two functions and thereby achieve greater efficiency in each, but in backward areas the full confidence of the population must be won by curing disease before any attempt is made to improve sanitary conditions. Thus a disease such as yaws, which can usually be cured by a short series of injections, is often a godsend to the sanitary worker. For friendly instruction in elementary hygiene when confidence has been obtained, a knowledge of the vernacular is essential.

2. Health officers, however zealous, can achieve little without full co-operation from other departments such as administrative, agricultural, veterinary, education, and police. There is no doubt that the importance of sanitary improvement would be better appreciated by officers in other departments if they had the opportunity of attending courses on the subject in home countries.

3. In an under-nourished population, especially if it is subjected to periods of famine or semi-famine, the mere treatment of disease is insufficient. The first need is a continuous supply of sufficient and well balanced food for the native, and the next, improvement in housing. Both aspects depend on the economic status of the community.

4. The teaching of hygiene, sanitation, and food values should be given a prominent place in school curricula and should be essentially practical, provided it is remembered that in hygiene 'parrot' rules are of little value without some background of biological understanding. The education of adults at hospitals, village gatherings, and other meeting-places can be furthered greatly by the use of lantern slides and cinema films.

5. Progress in preventive and curative medicine depends largely on the efficiency of African subordinate staff, and training at the principal hospitals and in special schools requires continued emphasis, particularly the training of native women in midwifery and child welfare work. Unfortunately women with the requisite elementary education are still rare in many territories.

6. The growth of air transport in Africa has now reached a stage when aeroplanes could be more widely used for transporting patients and medical and sanitary personnel with advantage to efficiency and economy.

7. Knowledge of African food supplies, and the possibility of improving them, is still very inadequate.

The provision of facilities outlined above appears to be more advanced in those territories under indirect rule. In Uganda a system of sub-dispensaries is already established; it has been described authoritatively by W. L. Webb (1934) and will serve as an example. Each sub-dispensary is a unit situated amongst a rural population in charge of a trained native attendant and supervised at regular intervals by a medical officer. Curative measures are first introduced, then preventive measures such as vaccination and inoculation; and when native interest is well aroused health propaganda is undertaken.

Infant mortality in most parts of Africa is very high; recent published estimates range from 100 to 500 per 1,000 live births. This has made the development of maternity and child welfare clinics a question of great importance. The great decrease in infant mortality in England was due to the improvement of general hygiene, and the establishment of infant consultation clinics. This increase, however, has been counterbalanced by artificial birth control. The adoption of contraceptive methods by Africans is unlikely to become general in the near future, so that pressure of population in congested areas is a development which must be reckoned with as infant mortality is reduced.

Mrs. McD. Hendrie has pointed out, on the basis of experience in the Gambia and Gold Coast, that the common belief that native women have little trouble during pregnancy and parturition is entirely unfounded. Numerous complications occur, most of which are caused or accentuated by disease, especially malaria, intestinal worms, and venereal diseases, and some by the impatience of native midwives. During the ante-natal period women are very ready to attend clinics and dispensaries, but as soon as labour commences they prefer to be among their own people, so that the provision of medical assistance becomes more difficult. The period of nursing, which among many African people extends to two or three years, is again a time when advice is readily taken by mothers, and is a time moreover when deficiencies in diet come into particular prominence. Many tribes attempt to make good these deficiencies by eating such materials as salt-containing

earths, but such additions to diet could be provided in more effective and hygienic forms by the nearest dispensary.

The work of Sir Albert and Lady Cook in Uganda has done much to improve female education by providing an outlet for trained girls in nursing and midwifery. The importance of the co-operation of all departments in measures to improve the general standard of life, which has been frequently emphasized in this volume, is now widely recognized. One might quote in illustration of this point a paragraph by Dr. Williams, Director of Medical and Sanitary Services in his annual report for 1933 (p. 17): 'It is interesting to note that in the report of the recent survey undertaken by the Agricultural Department the importance of co-operation between that department and the Medical Department is emphasized and there is no doubt that the measures to be adopted in endeavouring to secure a diminution in the incidence of disease are those measures which are directed towards raising the standard of living and to the improvement of the methods of agriculture and stock raising. Such measures to be effective require the co-operation and co-ordination of four departments in particular, viz. the Agricultural, the Medical, the Educational, and Veterinary. Much may be accomplished without any great expenditure of funds by these departments working in harmony and unison under the ægis of a keen and capable administration.'

In another part of the report (pp. 29–31) Dr. Williams outlines a scheme for co-operation between the departments to promote prosperity among rural natives. It includes improvement in agricultural methods, stock, water-supplies, communications, afforestation (the action of the Nyasaland forest department in establishing village forests has been mentioned in Chapter VII), the provision of schools for girls and women, public health and medical work, and propaganda by native teachers, dispensers, and sanitary staff.

FOOD AND NUTRITION

The conclusion that the improvement of health in Africa is largely a question of better food supplies reflects the general

tendency of medical science during the past few years. This movement has led to the publication of many general works on diet, which have value for Africa as for all other parts of the world; for example the League of Nations' publication on nutrition and public health by Burnet and Aykroyd (1935) and the volume on dietetics in warm climates by Leitch (1930). The Pan-African Health Conferences in South Africa in 1932 and 1935 paid particular attention to nutritional problems, as mentioned in the last of the general principles of rural health and hygiene (p. 570). For some years a committee of the International Institute of African Languages and Cultures, consisting of anthropologists and other scientists, has been elaborating plans for research on African native diets. A special number of the Institute's journal, *Africa* (April 1936), was devoted to the subject, and a separate publication by the Institute (1937) contains a full bibliography together with tables showing the composition of African foods compiled by the Imperial Bureau of Animal Nutrition. In 1936 a dispatch from the Secretary of State (Colonial Office 1936b) to all the colonies and dependencies, invited particular attention to these problems, and a special committee of the Economic Advisory Council was formed to survey the present state of knowledge in the Colonial Empire and advise on measures to promote the discovery and application of knowledge in this field.

A Dietetics Committee of the Economic Advisory Council had already inaugurated extensive researches in Kenya. The work was made possible by grants from the Empire Marketing Board to enable research officers from the Rowett Institute at Aberdeen to work in East Africa in collaboration with the Kenya medical department. From 1927 until 1931 a series of technical papers by Kelly, Henderson, Foster, and Harvey were published and have been summarized in special reports of the Dietetics Committee. In 1931, Sir John Orr, Director of the Rowett Institute, and Dr. J. L. Gilks, late Director of Medical and Sanitary Services in Kenya, who had collaborated in the field, published a report (1931) on the nutrition of the Kikuyu and Masai, in which were embodied all the principal results by other workers.

The two tribes selected represent the two ends of the nutritional

scale, the Masai subsisting on little else but meat, blood, and milk, and therefore having a diet high in protein, fats, vitamins A, B, iron and calcium; while the Kikuyu diet, being chiefly vegetable, is high in carbohydrates and low in protein, vitamin A, iron, and calcium. Since the physical development of the Masai is on the average much better than that of the Kikuyu, and the diseases from which they suffer are different, the question is raised of the relation of physical development and resistance to disease to food and nutrition. Much attention was paid to the mineral constituents of diet, especially calcium; it was ascertained for instance, that the Kikuyu have considerably less blood calcium than Europeans, and that the routine diets in hospitals and prisons contained only one-third of the assessed calcium requirements. A proper correlation between disease prevalence and diet deficiency has not yet been reached, but certain diseases seem definitely to show a dependence on unbalanced diet associated with normal blood chemistry. Tropical ulcer, for instance, is invariably associated with an abnormally high inorganic phosphorus content in the blood, although vitamin deficiency is almost certainly an additional cause of the disease. A further point is that the women on the whole have a more varied and better balanced diet than the men. The report stresses throughout that the results achieved are only pointers to the directions in which fuller research should proceed.

Studies of a somewhat similar nature were made at the same time in Nigeria, particularly by Dr. W. E. McCulloch, formerly dietetics expert in the medical department, working at the Katsina laboratory. His technical papers and notes in the annual reports of medical and health services (especially that for 1932) are highly illuminating. As regards tropical ulcer, McCulloch (1928) suggests that 'dietetic ulcer' would be a better name, since in his view they result from a chronic semi-starvation which facilitates the entrance of any mildly pathogenic organisms. This largely corresponds with the views of Connell and Buchanan (1933) based on an investigation in Tanganyika. McCulloch's treatise on the Hausa and town Fulani (1929–30) provides full data on the different foods eaten. Although a large variety of foodstuffs are grown, nearly all the population lives on millet porridge,

adulterated sour milk and a soup made from leaves of the baobab (kuka) tree, which analysis shows to have a peculiarly high calcium content. Groundnut oil and meat are daily additions for rich people, but are rarely eaten by the general population. He considers that the failure of a dietary in quality rather than quantity may easily be overlooked because of the erroneous idea that specific deficiency in diet must be observable in the form of special diseases. In actual fact the majority of specific deficiencies result in a general lowering of vitality and resistance to disease, as originally pointed out by Sir Robert McCarrison (1921).

Among the Hausa of Nigeria the low birth rate is attributed to infertility among the women. This suggested a general deficiency in vitamin E, and in order to put it to proof, exhaustive experiments have been made at the Katsina laboratory by feeding rats with typical native foods: almost invariably a reduction in fertility has resulted, but it seems that these results on fertility are not conclusive, since changes in diet, other than those resulting in deficiency, may effect the fertility of captive rats. McCulloch attaches importance to calcium deficiency in relation to fertility, and points out that certain villages which are well known among natives for their fertile women are those where the kuka trees grow in profusion. The poor quality milk is likewise attributed to calcium deficiency, and it is suggested that the long period (two or three years) of lactation is an adaptation to give the child a certain modicum of this element. It is interesting to note that McCulloch's figures for growth-rate show an abrupt arrest after puberty, and in this respect are similar to the figures recently collected by Dr. Gordon in Kenya (*see* pages 584–6). In general the West African tribes considered may be said to suffer diet deficiencies in vitamin B, vitamin E, calcium, iron, iodine, and protein.

Since the publication of these results, biochemists have been added to the scientific staff of medical departments in order to carry out among other duties, the analysis of local food materials. Among investigations, the results of which are published, may be mentioned that carried out in Zanzibar by Harden Smith (1935) and a nutritional review of the natives of Zanzibar (1937), which is one of the first fruits of the Colonial Office circular mentioned

above. In Sierra Leone Dr. E. J. Wright (1930 and 1936) has given special attention to avitaminosis among the local peoples. From the Sudan there comes a striking instance of what appears to be a direct deficiency disease among a people whose staple food is millet, as recorded by N. L. Corkill (1934). Some medical authorities have expressed the opinion that it is incorrect to call the disease in question pellagra, but it must certainly result from malnutrition. In Tanganyika an administrative officer, R. C. Jerrard (1936), has put together some data on customary foods in a pamphlet on the tribes of the territory.

In the Union of South Africa the nutrition of native races is also arousing interest, and F. W. Fox (1934 and 1936), of Johannesburg University, has already discussed some aspects of the question and has amassed a large collection of native food materials, many of which have been analysed. Such work is, of course, an essential preliminary to detailed diet surveys, and Fox (1934) has laid down a scheme for a general nutritional survey of the Union.

In the Belgian Congo it appears that little direct work on the food and nutrition of natives in rural areas has yet been attempted, but in mining regions the subject has been studied in some detail with a view to preparing the most suitable dietaries for labourers. Much research on the different food materials in use throughout the Congo has been done through the agency of laboratories at Tervueren near Brussels, attached to the Congo Museum, and some of the results are displayed in the public galleries of that museum. In the French African colonies nutritional work is somewhat dispersed and special research has not yet been attempted in the field. A general protein deficiency in the diet of non-pastoral peoples is fully recognized, however, and a movement is afoot to produce dried meat and fish as articles of internal trade in order to make good this lack. A valuable book on the food of native races in all the French colonial dependencies has been written by a group of scientists, including Professor Labouret and Dr. Sorel (Hardy and Richet 1933).

It is perhaps a little surprising that the better-known deficiency diseases, such as beri-beri and rickets, are not very serious in

tropical Africa. They can, of course, be cured by nutritional methods where medical aid is available, as a result of fundamental research carried out in Europe and in the East during the last twenty years. There may, however, be a number of local deficiency diseases whose presence is masked by the numerous better-known diseases from which natives suffer. To mention one example, in Nigeria a disease involving blindness has been evident among people who feed largely on cassava. It has been noticed particularly in school children among whom the disease has been cured by feeding with cod-liver oil. Similar complaints have been observed in other parts of Africa and the value of vitamin A as a protection from infection has been stressed by Fox (1933). The blindness in Nigeria may be a disease known in European countries to be a direct result of vitamin A deficiency, but opinion is divided and some authorities consider it to result from some toxin in the food. Dr. Clarke investigated this question in Nigeria during 1935 and 1936 under a grant made by the Medical Research Council and Colonial Medical Fund, and his conclusions give weight to the view that poisonous substances occur in appreciable quantities in cassava and coco yam. Thus the avitaminosis is probably caused by food toxins which do not allow the vitamins to be used properly by the body.

The relation between nutrition and resistance to disease was the subject of an important discussion by the British Association in 1935. The opinion is often expressed that susceptibility to parasitic worms is enhanced by malnutrition. There is, in fact, some experimental evidence in animals in support of this view, discussed by Miss P. A. Clapham (1933). Nearly every native has worms of one kind or another, and a recent work on the zoological content of male and female natives' intestines, though at present based on small numbers, indicates that women have considerably fewer worms than men. It has been suggested that this is due to the more varied diet of women, but it is also possible that infestation by helminths depends on the facilities which the parasites have for distribution from host to host rather than on the food of their hosts. If susceptibility to worm parasites is partly a result of malnutrition it is important to remember that the converse is probably true, that infestation with intestinal parasites favours the develop-

ment of malnutrition and food deficiency by interfering with digestion and absorption.

The dependence of teeth on diet is another question of striking interest. Sir Edward and Lady Mellanby have pointed out that dental caries among Kikuyu natives in East Africa is more prevalent in towns and mission stations, where natives wear clothes, than among untouched members of the same tribe living a rural life. They attribute this partly to the deficiency of calcium and vitamin D in the diet, but also to lack of sunshine directly on the body, and to the shortened period of breast-feeding which results from town life. This conclusion was confirmed by Oranje, Noriskin, and Osborn (1935) for the South African Bantu. 'The percentage of Bantu having carious teeth', they state, 'and the average number of caries per individual are lower in relatively primitive Bantu than in those who have had a closer contact with Europeans by working on farms, in mines, or in towns.' Dr. Osborn is continuing this study on a larger scale in the native territories of South Africa and the Johannesburg mine compounds. On the other hand, there is reason to suppose in some areas that natives in the reserves have bad teeth as a result of food deficiency, but in towns the varied diet results in improvement. The deficiencies which are involved in causing dental decay, either singly or in various combinations, are those of calcium, phosphorus, vitamins A, D, and C, and lack of oral hygiene likewise plays its part. A study of these factors among both urban and rural natives offers a great opportunity for research.

The monotony of native diet has been found to be of great importance, since it means that deprivation of any constituent, even if normally taken in very small quantities, may result in the complete absence of some essential substance. This monotony is perhaps most strongly marked among pastoral peoples such as the Masai. It is less obvious in agricultural tribes whose diet changes during the year, and who use an astonishing variety of relishes. The diet of cultivators, however, though varied, is seldom well balanced, and it seems probable that a series of deficiencies occurs throughout the year as the food changes from month to month. In labour camps and prisons, the effects of monotony in diet have sometimes been very serious. The high mortality of prisoners in

Uganda, for instance, has been very considerably reduced by the institution of a varied dietary particularly rich in vitamin A, as pointed out by Owen and Mitchell (1931). Again, the Médecin-en-Chef of the Belgian Congo, discussing cases of beri-beri and rickets in his annual report for 1931, notes that 'les avitaminoses sont essentiellement des maladies des camps des travailleurs et des prisons'. Now that the source of the trouble is recognized, the position has been much improved, as shown by Dr. Trolli (1936) for the Belgian Congo and Dr. A. J. Orenstein (1936) for the Witwatersrand gold mines.

Deficiency of certain minerals, especially those containing calcium and phosphorus, is common all over the continent and natives go to great pains to make good the lack. Everywhere salt, particularly natural salt, which contains a variety of constituents in addition to sodium chloride, is a most valued article of trade, and natives sometimes travel great distances to obtain supplies for themselves and their stock, or drive their stock periodically to salt licks. In many places earth from special areas rich in salts is regularly eaten and in some cases, especially among nursing mothers, young children, and people suffering from intense infestation by parasitic worms, the desire for special earths as food develops into pica, or a depraved craving, as described by J. W. Foster (1927) for East African natives. Often Africans obtain meagre supplies of mineral salts, especially calcium, from the tissues of plants; thus in parts of Rhodesia, Kenya, and Uganda reeds are burnt and salt obtained from the ashes by a process of solution and reprecipitation. In Nigeria the leaves of the baobab tree, which chemical analysis shows to have a peculiarly high calcium content, are crushed and eaten in soups. The latter case provides a striking illustration of the dietetic value of a customary native practice. Precautions are always taken to avoid direct sun on the leaves during the drying process, a practice for which a very sound reason has been elucidated by laboratory analysis and experiment: it has been shown that sun-drying as opposed to shade-drying destroys the vitamin content of the leaves.

Examples such as this show the importance of full understanding of traditional native attitudes towards different articles of native diet and their preparation, as a preliminary to measures of improve-

ment. Nevertheless, the diet could in some respects be altered for the better without much difficulty, as pointed out by many writers, in particular Sir Daniel Hall (1936), who discusses the food of Africans together with the related subjects of agriculture and animal husbandry. In Nigeria groundnuts, which are widely grown for export, would help to make good the protein deficiency if developed as an article of consumption. Leguminous crops as an addition to native diet are being tried in parts of the continent. Soya beans, particularly, contain proteins of high nutritive value. The lack of calcium could perhaps be reduced by a more extended use of sweet potatoes, which are said to contain a higher proportion of this element than other native foodstuffs in West Africa, though this result is not confirmed in Kenya, where the lowest limit of calcium for sweet potatoes was found to be lower than that for European potatoes.

Red palm oil, which is produced in large quantities in West Africa, offers another opportunity for extended use as native food. A recent study of this oil at Singapore by Rosedale and Oliveiro (1934) shows that 'in addition to the ordinary energy-giving quality of an oil, red palm oil is the only oil possessing vitamin A, which could at the same time become available as food for the population'. As a further point in its favour the vitamin content of red palm oil appears to be less quickly activated into vitamin D than that of coconut and other oils. Vitamin D is probably nearly always sufficient in tropical diets, but too much of it works as a calcium activator, which means that the usual deficiency of calcium in native diets is increased by too rapid utilization. An investigation on the value of palm oil in prison diets and of the vitamin content of local oil is proceeding in Tanganyika.

The problems involved in efforts to increase the consumption of dried meat as a source of proteins have been discussed in Chapters XIII and XIV. Again a fuller use of the continent's fishery resources, both marine and freshwater, discussed in Chapter IX, offers special opportunities for the improvement of diet, since fish food provides not only protein, but calcium, iodine, etc., in the most easily assimilated form. As a further source of animal protein, insects are used as food in most parts of Africa: certain stages in the life-history of termites are regarded as a luxury, a

nutritious cake is made from the compressed bodies of lake flies near the great lakes, and some tribes are fond of locusts. Here again there may be opportunity for expansion.

Preliminary investigation should be directed to studies of the metabolism of natives, and standard analyses showing the dietetic value of the normal food materials. The former of these subjects is discussed on page 584; some remarks on analyses may be made here. Food analyses are more easily made in the well-equipped laboratories of Europe and America than in Africa itself, but facilities are now developing in Africa, especially in the Union. The analysis of foodstuffs in Africa itself is a less formidable task than it sounds, especially now that most of the important vitamins can be analysed by chemical and physical methods. In this connection results from the League of Nations Permanent Commission on Biological Standardization will be of value, particularly in international co-operation; for instance, the commission has set up official units and standards by means of which the vitamin contents of food and the amounts required for maintaining health can be estimated. In addition, the work done at Washington, D.C., in analysing typical food materials, should be applicable in other parts of the world, but would need to be supplemented by work on African foods. At the Conference of the Co-ordination of General Medical Research in East Africa (Conference, East Africa, 1934a) it was decided that all analyses of local foodstuffs should be carried out by the biochemist at the Nairobi laboratory. The studies which have already been completed at Nairobi and elsewhere in Africa (International Institute of African Languages and Cultures 1937) stress the importance of local variation, so that general standardization of each food material is not sufficient. The nutritive value of different food crops must vary, not only with different strains, but with conditions of soil, climate, use of manure, and irrigation. Some local products can be sent to distant laboratories for analysis, but this is unsatisfactory, particularly for determinations of vitamins A and C, because alteration of these is rapid, consequent on oxidation, storage, etc. The existence of local variations does not, of course, detract from the importance of general standardization.

When the value of each foodstuff is known, diet charts can be

made out and the knowledge distributed by propaganda methods, as in Europe and America. In some tropical countries outside Africa this is already being done. In Malaya, for example, sheets are published showing dietetic values of all the principal foodstuffs, and a tropical diet chart illustrates a number of minimum dietaries. Professor Rosedale of the biochemical laboratory at Singapore has been active in spreading knowledge in Malaya by such means. Some of the results are applicable in parts of Africa, and the Malayan sheets are exhibited in the food section of the museum at Zanzibar.

Further studies may be divided into two stages: (i) the survey stage, consisting of general studies of existing conditions, combined with surveys of the distribution of diseases, and (ii) the experimental stage, consisting of detailed work on individual villages where experiments can be made by changing the dietary.

The contribution of the social anthropologist to dietetic studies has been elaborated in detail by Raymond Firth (1934), and the results of anthropological work on diets in Northern Rhodesia have been published by Dr. Audrey Richards and Miss Widdowson (1936), and in the Northern Territories of the Gold Coast by M. and S.L. Fortes (1936). There have also been several local studies by Government officers, sometimes of medical and agricultural departments in co-operation; for example, in Uganda two agricultural officers and a medical officer recently made a joint nutritional study in the Teso district; in Tanganyika similar surveys are in progress. Expert medical investigation seems to be essential in such surveys, since many variations in the incidence of disease are associated with differences in diet. To take the most obvious case, a meat-eating pastoral tribe is likely to suffer from lack of carbohydrates, while a neighbouring grain-eating tribe requires animal protein. Africa, at the moment, may be compared with a nutritional laboratory in which innumerable experiments on controlled diet have been progressing for a hundred years or so. Much may be learned by simply collecting the results of these experiments, but this knowledge will be far more difficult to attain in a few years time when local food customs have broken down with the disintegration of tribal organization. In some parts of the continent, moreover, there are living isolated

tribes which appear to be dying out as a result of peculiar nutritional diseases. There is a striking instance of this in one of the least-known parts of East Africa, at the south-east corner of Lake Rudolf where there lives a dwindling tribe, the Elmolo, studied by the Cambridge Lake Rudolf Expedition of 1934. Brief reference to them is made by V. E. Fuchs (1935), who points out that among the remaining members of this tribe, numbering about eighty-four, there is an almost universal deformity of the shin bones. The Elmolo live entirely on fish, crocodiles, and turtles that are caught in the lake, and drink the lake water which has a very high soda, and an almost negligible calcium content. The results of this very peculiar dietary are seen in the prevalence of scurvy, pyorrhœa, dental decay, and arthritis in addition to their malformations of bone. This example is mentioned as a case where a small and comparatively inexpensive investigation could obtain results of remarkable value. It is practically certain that the condition of the Elmolo results from mineral deficiency combined with insufficient intake of certain vitamins. A medical and dietetic survey would give results which, apart from their own intrinsic interest, might indicate the cause of similar physical complaints among people who normally enjoy a more varied diet.

The nutritional significance of vegetable relishes used by agricultural tribes involves botanical as well as dietetic inquiry, as does the variety of local strains of staple food materials. Mr. H. C. Sampson, Economic Botanist at Kew, has already large collections of millets and other food grains from several parts of Africa and is in active co-operation with the local agriculturists and other officers. In South Africa the Division of Plant Industry of the Union Government has a number of botanists ready to identify and study important plants, while F. W. Fox and his collaborators at the South African Institute for Medical Research, have already examined a large number of wild plants used as food, particularly those which become important in times of acute shortage (Levy, Weintroub, and Fox 1936).

Experimental work in the modification of the dietaries of selected villages or families should not be very difficult to arrange. With the knowledge gained from survey studies, small additions might be made to test the results on the prevalence of particular diseases.

In Europe, Dr. Aykroyd, when a member of the League of Nations Health Section, started experiments of this kind on certain families in Roumania, in connexion with the prevalence of pellagra. The greater uniformity of African diets should make controlled methods in such research easier than in Europe.

Such experiments call for specialist knowledge from a number of different fields. It seems that results could be achieved best by a special team of workers sent out from Europe—say a doctor, a biochemist, a social anthropologist, and an agriculturalist. Given twelve months in an area carefully defined to present a few major problems, results should be expected which would be of the first importance to Africa, and indeed to the world as a whole. Apart from such special work, however, it would be desirable that the training of medical officers for work in the tropics, should include nutrition as an important subject.

In several British colonies dietetics committees have been set up in which medical, agricultural, forestry, veterinary, and geological departments co-operate. It is worth noting also that, in spite of the prevalence of diseases in Africa, for which malnutrition is partly responsible, a high level of physique and health is often attained by individual members of African tribes on diets of extreme simplicity. In this respect Europeans may have something to learn, as well as to teach.

PHYSIOLOGY AND DEVELOPMENT OF AFRICANS

The necessity for fundamental research on the physiology of African races was stressed in strong terms by the Pan-African Health Conference of 1935. The subject had already been discussed at the conference of 1933 on the Co-ordination of General Medical Research in the East African territories (Conference, East Africa, 1934a), when it was decided that such work should be inaugurated at the medical research laboratories at Nairobi, the necessary apparatus being purchased by contributions from the several territories. Until some standards of normality have been established for the metabolism of natives, any appreciation of deviations from the normal and any steps taken to correct them, must remain largely a matter for conjecture. Normal figures for the *basal* meta-

bolism of natives, though of considerable academic interest, are not perhaps immediately required, because carbohydrate food to give calories is always the least expensive part of a diet, and this is particularly so with the type of food usually available for native races. An inquiry into the *general* metabolism of natives is, however, of the greatest importance in elucidating how the African differs from the known standards of Europeans. Research on these lines would require accurate biological, biochemical, and biophysical estimations, involving work both in the laboratory and the field, with the clinician and the pathologist assisting with the provision of normal and pathological material. Such work has been started at the medical research laboratories both in Kenya and Tanganyika, but results have not yet reached the stage of publication.

The subject of the African's development has recently come before the public notice after the publication of Dr. H. L. Gordon's and Dr. F. W. Vint's preliminary results in Kenya, and of the former's appeal for funds to extend the work.

It has been recognized for many years by physical anthropologists that the average size of the brain, like that of any other measurable characteristic, varies among different population groups. Dr. Gordon's work includes the further attempt to compare the rate of brain growth among natives and Europeans. His data, which are admittedly of a preliminary nature, show that at ten years old the average native brain is much smaller than the European, and that it grows at about half speed until at twenty years it is about the size of the European brain at ten years. A secondary point of more importance is that growth of the native brain is arrested at the time of puberty and continues afterwards at reduced rate, while in Europeans growth is accelerated after the onset of puberty.

The direct correlation between size of brain and intelligence cannot be presumed, and indeed there are many experts who would deny any correlation whatever, but some preliminary histological work gives Gordon's results greater significance. The work on brain measurements on living natives was coupled with macroscopical and microscopical examinations by Dr. Vint (1934), pathologist to the Kenya Government, who claims to have shown

that the brain cortex (grey matter) of the native is qualitatively deficient compared with the European's: the individual pyramidal cells of the cortex are smaller, less well-formed, with a preponderance of undifferentiated cells. These results are not, however, at present accepted as conclusive by experts. In another part of the world, the extensive investigations made by Professor Shellshear (1937) on the brains of Australian aborigines and of Chinese have shown that the two groups are characterized by differences in structure; but it should be noticed that he expressly refrains from basing on these results any conclusions with regard to differences in mental capacity, while pointing out that so far as biological evolution is concerned, the retention of primitive characters in the so-called 'lower' races may provide the possibility of greater evolutionary advance.

Dr. Gordon published a summary of his conclusions on the brain in a letter to *The Times* of 8th December 1933, which called forth an abundance of criticism, particularly against his methods of calculating brain capacity from the measurements of the living head, and in the presentation of results as absolute brain size rather than relative brain size, taking into account the size of the body. Dr. J. S. Huxley, in a letter on the subject dated 18th December 1933, pointed out that the only true criterion is relative brain size based on Lapicque's formula for different types of mammals: the brain varies as the body weight raised to the power 0·56. There was also some doubt whether the natives examined represented a true sample of the populations concerned. Most people are agreed, as Drs. Gordon and Vint themselves maintain, that the results to date are merely pointers, but that the subject is one on which exhaustive work is required.

Apart from the study of brains, which naturally attracted public attention, Gordon (1934) recorded a number of other suggestive facts relating to physical development. In characters such as sitting and standing height, weight, hand grip, and vital capacity, the native at the age of ten is better developed than the European, but is overtaken at about fifteen years, after which the native's development falls off, while the European's leaps ahead. When speaking of the 'native' it is important to realize that Gordon's results are based mainly on the Kikuyu mixed with some Nilotic

Jaluo and a few individuals from other tribes. The East African tribes present such striking physical differences that further inquiry will be of great interest for purposes of comparison. As mentioned in the previous section, Dr. McCulloch has collected data from the Hausa of West Africa, which show similar arrest of physical development at puberty.

Since the publication of results by Gordon and Vint the medical and lay press has made constant reference to the possibility of a large-scale inquiry, and the combined meeting of the East African branches of the British Medical Association at Dar-es-Salaam in January 1934 passed a resolution calling upon the governments to take up the investigation without delay. The inquiry is estimated to cost about £50,000 and, with the annual medical grant in Kenya at about £200,000, it is clear that such a sum could not come from local budgets. Sir Ernest Graham-Little, M.P., has put the arguments in favour of making such a sum available in *The Times* of 28th August 1934.

It should be urged that knowledge of mental and physical development, though of great academic interest, is not sufficient as a guide in formulating policy. It should be combined with a survey of diseases, of nutrition, of agricultural and animal husbandry methods, and even botany, zoology, soils, etc. In fact, the ecological outlook would be all-important in such an inquiry in order to understand the several factors working on native development, and to appreciate which of them are susceptible to control. Since so much intensive work is necessary, it seems that the best results would accrue if a team of workers were to concentrate in the first place on one tribe, or perhaps one small section of a tribe. A deep insight into the question of natural development would thereby be attained, and standards would be set up; these could subsequently be applied with comparatively little extra work to other tribes living in different environments.

HEALTH OF EUROPEANS

Compared with African natives, Europeans are comparatively well-provided with medical facilities, as pointed out in Chapter XV. Civil servants receive free attention from the government

medical services, and there are not many stations now which do not either have a resident medical officer or receive frequent visits from one, while private practice and nursing homes are well established in all urbanized, industrial, and closely settled agricultural areas. In the principal towns, where white population is large, hospitals reserved for Europeans are as good, or nearly as good, as anywhere in the tropics, and subsidiary European hospitals are established in nearly every township in the settled areas.

On the much-debated question of deterioration in health under tropical conditions, a few figures may be quoted from H. E. Rayne (1930), showing the enormous improvement which has come about during the last forty years. The most accurate data are for civil servants in the Gold Coast and Nigeria: in 1881–97 the annual death rate per 1,000 was 75·8 in the Gold Coast, and 53·6 in Lagos. Since then there has been a steady and rapid decline, only interrupted during the war years as a result of overwork and lengthened tours. In 1925–8 the death rate was 6·5/1,000 per year at the age of 25, 12·1 at the age of 45, and 9·3 at ages over 50 (the last figure is perhaps misleading since many officers retire before 50 years of age). Similar figures could be quoted for other tropical dependencies, but the improvement is not so striking because the initial mortality rate in East and Central Africa was not so high as on the West Coast. Of course all classes of the European community do not enjoy the same health; for example, missionaries as a group have a comparatively high mortality and invalid rate. This is sometimes interpreted as the result of a low standard of comfort, but may equally well be due to the greater risk of infection for persons in close contact with the native population. Figures show that in recent years the mortality rate for retired officials is not appreciably higher than the normal for Great Britain for similar age periods. Mortality rates in the Belgian Congo remain somewhat higher than in British Africa. This must be partly, perhaps wholly, a result of the larger proportion of European children in the Belgian territory, since children in the tropics have always a higher mortality than adults.

The great improvement of health in Africa among Euro can has clearly resulted from an all round improvement in the stan-

dard of living and general amenities of life. The quality of food, in particular, has improved markedly; more fresh food is available for purchase locally, the quality of meat has risen, and in quite recent years the advent of small house refrigerators has enabled many Europeans to preserve food adequately and to render it more palatable and more easily digestible. New methods of house building with metallic foil-covered asbestos as insulating material, tiles instead of corrugated iron, etc., have made living conditions more comfortable. The general conclusion may be stated that for Europeans to maintain health in unhealthy African districts a high standard of living is essential. Many amenities of life which are regarded as luxuries in England are necessities in the tropics, and if this is realized there appears to be little, if any, deterioration in health.

The problems of European health in the Union of South Africa are in some ways different from those in other parts of the continent, the climate on the whole being considerably more favourable and the European population more numerous. The health of the white man in the Union was considered at some length during the Medical Congress held at Grahamstown in September 1935, and the papers presented are published in the *South African Medical Journal.* The general problems of the 'poor whites' who represent about 15 per cent of the European population, at a very low standard of living, were the subject of an inquiry carried out in 1931 with the help of the Carnegie Commission. The resultant report (1932) contains valuable information on diet, as well as other questions.

There is still, however, room for the investigation of some underlying scientific problems. Our limited knowledge of African physiology has already been mentioned. With regard to white races, a mass of research has been carried out on physiology in temperate conditions, but ignorance is still profound on the effects on the functioning of the body and brain caused by life in tropical climates. It is not yet known, for example, how such factors as tropical sunshine and humidity affect the system.

Another factor, which must influence the future of some settled areas, is the effect on Europeans of life at high altitudes. Full results cannot be expected until Europeans have lived in their new

environment for at least two or three generations, but already there are indications that the rate of physical and mental development, the onset of puberty, etc. are different in the Kenya Highlands from England, and it has been suggested that these differences are associated with blood pressure. Some other effects of climate on health are mentioned in Chapter IV.

Turning to a subject of more immediate practical importance, research is required on tropical housing and clothing for the white man. What we do at present is more conventional than reasonable. The new non-tarnishing metallic foils, in particular, are bound to be valuable as heat insulators; they are already being used in roofs and hats. The conditioning of air in houses, offices, and trains, and perhaps even motor-cars, is another application of science which may well revolutionize European life in some parts of tropical Africa. In this subject America has given the lead to the world; all over the Eastern States public offices, theatres, and trains are now kept at a constant optimum temperature by thermostatic devices. In most tropical countries, as mentioned in Chapter IV, humidity is perhaps a more potent influence in health than is temperature, but research has already shown how humidity in buildings can be controlled. It seems that some of the devices for air conditioning, now employed in America and Europe, could be applied with little modification in many tropical townships and railways, and lead to great improvement in European health and efficiency.

CHAPTER XVIII

ANTHROPOLOGY

INTRODUCTION

THE methods of life of the African native have been found to be relevant to the subject of each of the foregoing chapters, with the exception of those on Surveys and Geology, and even these two subjects bear on African life in the light which they throw on the physical environment. Hence this study of science in the African continent necessarily involves some reference to anthropology.

Modern anthropological studies are largely directed to an analysis of those institutions, economic, political, and legal, on which the everyday life of the native is based, and the changes which these are undergoing in response to the various agencies of European contact. The policy of Indirect Rule seeks the development of native political institutions to meet the needs of modern times, and it is generally recognized that the study of social anthropology may assist this form of relation, between controlling power and subject race, to be efficient.

It is sometimes argued that the administrative officer, whose duty it is to apply this political system, is best qualified to undertake the research involved, and there are many instances of valuable studies carried out by officials. But the necessary time is seldom at the command of the official, and, moreover, the very fact that it is he who has to apply the necessary changes may bias in some degree his view of the existing systems of native life. The work required involves time and special technique which are seldom at the disposal of the administrative official.

Anthropology is included amongst the subjects in the training course for probationers in the British colonial administrations, and

it is reasonable to foresee that there will be a steady and increasing flow of studies on individual tribes from the pens of administrative officers themselves; but men and women with a more intensive training in the methods of anthropological research must also find an important place in the African field. The part that is being and could be played by anthropology in relation to administrative departments is explained in the chapter on 'Studies in social life' in *An African Survey*, but in relation to other parts of this scientific volume, it can be demonstrated similarly how anthropology enters the sphere of the technical departments in any African territory. Many problems, connected with administration, but coming within the purview of agriculture, are those resulting from economic changes. The traditional social and economic order of native society is being changed by world economic conditions, which are quite beyond the control of Africa itself. Thus the cultivation of new crops for the world's markets and the demands for labour for European enterprises have profound and far-reaching effects on the family, the tribal organization, religious beliefs and sanctions, traditional morality and other branches of social structure. The effect of these changes may be disastrous unless there is an understanding of the native social and economic systems, and unless an attempt is made on the basis of adequate knowledge to replace them, where they are breaking down, by new incentives to labour, new values and new economic wants.

The developments in methods of production by Africans for their own subsistence also raise many anthropological problems. Detailed knowledge of native methods of cultivation is clearly necessary, since important practices may be overlooked by agricultural officers in their necessarily rapid surveys. Thus in one area a complicated five- or seven-year rotation of crops was discovered by a sociological research worker, whereas it had previously been presumed that the people in question had a haphazard system with no rotation. In another instance the question had to be decided by Government whether the food shortage during certain months of the year was acute enough to make it worth while to undertake the effort of introducing a new crop for native consumption. The only means by which this information could be obtained was by careful records of the nature and quan-

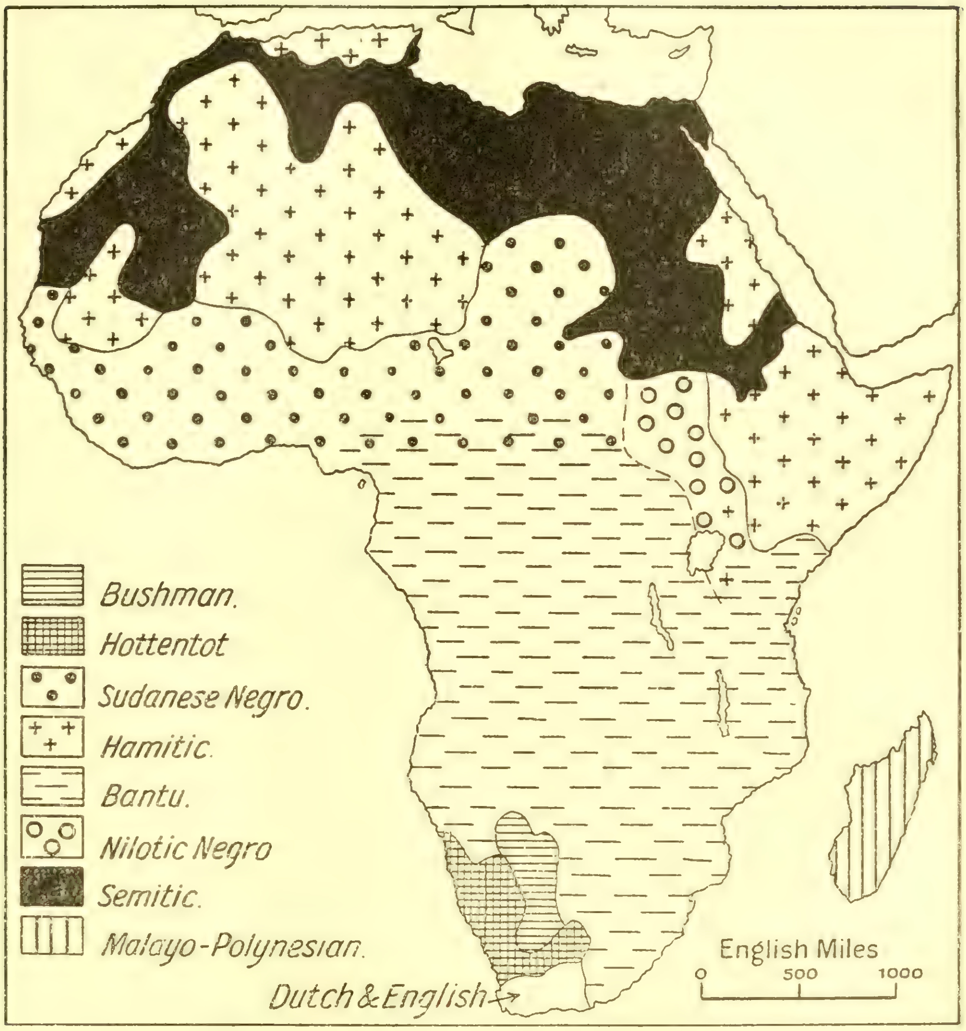
tity of the food supply from season to season, of the amount of food stored each year by the average householder, and of the quantity and type of food consumed during different months of the year by representative families.

Similar questions arise in connection with the overstocking of native reserves, which is one of the most pressing economic problems of Eastern and Southern Africa. Attempts to compel Africans to reduce their stock are bound to rouse determined opposition unless account is taken of the part played by cattle in the social organization of the tribe, of the religious beliefs and social values attaching to them, of their importance in the marriage contract and of their many other connections with the whole economy of native life. Only the scientific study of the interconnection of these social facts will make it possible for Europeans to understand the African's refusal to make what seems the obvious adjustment, and will provide the knowledge on the basis of which the problem may be attacked with some hope of success.

The subject of native food and nutrition has been considered in Chapter XVII. Once again, however, anthropology has an important part to play in obtaining the initial information about diets, and in explaining the part played by traditional economic organization and social structure in the production and distribution of food. The same may be said of all health work throughout rural Africa.

The development of co-operative societies (Chapter XIII) is a question of the first importance for the whole of Africa. Not only may the establishment of such societies contribute in important ways to economic development, but they may prove both a valuable actor in promoting social cohesion and also a substitute for native institutions which are no longer adequate to meet the changed conditions of life. Trained scientific workers can probably best discover how these new forms of social co-operation can be grafted on to existing African institutions and how the living forces and customary loyalties of native society can most effectively be developed and utilized for the achievement of new social purposes.

A field in which the need for further scientific investigation has become increasingly evident is the adaptation of education to the conditions and needs of African life. The principle of such adapta-



MAP 4. Principal Language Groups. (*After Fitzgerald, 1934.*)

tion is now widely accepted, but in actual fact educational programmes directly related to the realities of native life are comparatively few. Some attempts have been made to base the educational syllabus on the improvement of the crafts already practised in native villages and to relate agricultural education to traditional methods of agriculture, which are by no means as inefficient as is sometimes assumed. But in most territories much still remains to be done in this direction. New problems also arise and call for sociological investigation in connection with the absorption of the younger generation into trade, industry and the service of the Government. None of the educational problems to which reference has been made can be dealt with successfully without a much more thorough study of education both in relation to traditional native society and to the new requirements of western civilization. Probably the best popular account of the present position and future prospects in these subjects is that by Professor Westermann (1934).

In the remainder of this chapter a sketch is given first of the existing agencies for anthropological research in Africa. This is followed by summaries of recent work in several branches of the subject, in the compilation of which the survey by Dr. Edwin Smith (1935) has been of great assistance. Some of the subjects discussed are considered at greater length in connection with administrative work in *An African Survey*; in particular the science of linguistics has been omitted altogether from this chapter, apart from occasional reference, since it has little direct bearing on the other scientific subjects with which the volume is concerned.

ORGANIZATION

Anthropology was moulded into a science by workers in the far East, especially in Polynesia and Melanesia, and there are still comparatively few workers who have chosen Africa as their field of study. Consequently, in summarizing the present organizations for research, it is necessary to mention a number of individuals by name, a practice which is different from that adopted in the corresponding sections of other chapters. Anthropologists have come to the subject from many directions; some have approached it

through universities from biology, medicine, psychology, modern languages or classics; others have reached it through the channels of administration or missionary work in which everyday contact with native races has stimulated the desire to find out about the people and their ways of life. Consequently there are various methods of viewing the subject, some concerned primarily with the historical or archaeological aspects, some with native languages or with material culture, some with sociology and the changes due to culture contact. These different aspects are considered in later sections of this chapter.

In the sphere of research organized or partly sponsored by governments, Professor C. G. Seligman was the first anthropologist to be commissioned by an African Government to investigate for administrative purposes, and his work with Mrs. Seligman in the Sudan, which began in 1911, has done much to establish the science in Africa. Throughout several expeditions he served in an advisory capacity to the Government, though his work was financed to a considerable extent by scientific institutions in England. From 1926 onwards Professor Seligman's work in the Sudan was followed up by Dr. Evans-Pritchard, who has made special studies of the Azande, Nuer, and Annak tribes from the modern sociological standpoint (see below). He was likewise financed in a proportion of two to one by scientific bodies in England and the Sudan Government. Concerning purely government research, the late Captain R. S. Rattray was official anthropologist in the Gold Coast for a period of years, while Nigeria similarly supported Dr. C. K. Meek; both of these had spent many years as administrative officers before being seconded for research purposes. On the retirement of these officers there was no government anthropologist in British colonial territories until in 1937 the Rhodes-Livingstone Memorial Institute was established at Livingstone in Northern Rhodesia and Mr. G. Wilson was appointed to the post of anthropologist there. In the same year Dr. S. F. Nadel was appointed by the government of the Anglo-Egyptian Sudan to carry out a special survey of the Nuba hills.

Research undertaken by Government officers might be expected to be directly concerned with specific administrative problems, but, as in any other science, it has often proved that the work which is

most useful in the long run was undertaken with the rather different object of increasing the sum total of knowledge concerning tribal organization and culture, even down to the smallest details. Captain Rattray's books (see below), for example, do not profess to show how the Ashanti should be administered, but they are, nevertheless, referred to by every administrative officer concerned with the region. As a contrast, some publications by C. K. Meek, when anthropological officer in Northern Nigeria, provide examples of special administrative problems of the moment; but likewise, when gathered together, they serve as valuable reference works. A number of unpublished reports on native political institutions have resulted from studies made by individual officers in connection with the extension of indirect rule.

Among other Government officials who have contributed materially to the science, the following are prominent: in Kenya, C. R. Dundas and C. W. Hobley; in both Kenya and Tanganyika, Major Orde Browne; in Nigeria, J. R. Wilson-Haffenden; in Northern Rhodesia, A. M. Dale, who published two volumes jointly with Dr. Edwin Smith and F. H. Melland, who has contributed especially to knowledge on witchcraft; and finally, J. H. Driberg, who did much of his original field work when serving in the administrative departments of the Anglo-Egyptian Sudan and Uganda, and has since developed the teaching side of African anthropology at Cambridge.

Those anthropologists who have been missionaries and some of whom, therefore, have approached the subject from a rather different angle, should be headed by Dr. Edwin Smith, whose joint study with A. M. Dale, of the Ila-speaking peoples, has just been mentioned. Subsequently his more popular work, *The Golden Stool*, brought anthropology into closer touch with missionary, administrative, and other activities, and in 1934–5 he was elected President of the Royal Anthropological Institute, and of the International Anthropological Congress held in London in 1934. His presidential address to the Royal Anthropological Institute (1935) is particularly notable in drawing together the threads of anthropology into a general view, including some reference also to scientific work in other fields. In Eastern Africa, Canon Roscoe has done valuable work. Notable studies by missionaries on Southern African

tribes, are those by Dudley Kidd, Willoughby, and Dora Earthy. German missionary work in this field is prominently represented by A. W. Spieth in Togoland, B. Gutmann in Tanganyika, and Father Siebert in the Belgian Congo. An important contribution by a Swiss missionary on Portuguese East Africa is H. Junod's *Life of a South African Tribe.*

Among universities as centres for research and training in anthropology, the three most important in England are Oxford, Cambridge, and London. In South Africa, the leading university centres are Capetown and the Witwatersrand. The Oxford and Cambridge anthropological departments provide the training for all the colonial administrative probationers. Dr. R. R. Marett at Oxford, now succeeded by Professor A. R. Radcliffe-Brown, inspired several of the best known anthropologists of to-day to turn to the subject; at Cambridge the African teaching is mainly in the hands of J. H. Driberg. The London School of Economics is one of the leading headquarters to-day for training specialists for research in the field, and the outstanding teachers concerned have been Professor Seligman, whose monumental work in the Sudan has already been mentioned, and in more recent years, Professor B. Malinowski, whose emphasis on the functional as opposed to the structural aspect of the science has had a profound influence on the present generation of research workers and the relation between anthropology and administration. Malinowski's own contributions to research have been concerned with peoples outside Africa, but his views on the place that should be taken by anthropology in the African field are set down in several articles, especially those in *Africa* (1929 and 1930). The anthropological department at Capetown is under Professor I. Schapera, who has studied the Southern Bantu; at the University of the Witwatersrand, the department is in charge of Dr. Audrey Richards, who has worked extensively in Northern Rhodesia and who, in 1937, succeeded Mrs. Hoernlé, well known for her researches on the Hottentots.

The International Institute of African Languages and Cultures in London, working in conjunction with the London School of Economics as a training centre, has been developed largely by means of a grant from the Rockefeller Foundation, and since 1931 has been able to carry out a considerable programme of anthro-

pological and linguistic research. The journal, *Africa*, published quarterly by the institute, is devoted mainly to a better understanding of those aspects of native society making for social cohesion, the economics of communal life, the ways in which African society is being affected by the invasion of western ideas and economic forces, and the resulting changes in African institutions and behaviour. From 1931 to 1936 the institute has awarded thirteen full-time fellowships for research in Africa and a number of grants to enable workers to complete research already begun; under this scheme studies have been made in Sierra Leone, the Gold Coast, Nigeria, Ruanda-Urundi, Bechuanaland, Swaziland, Pondoland, the Transvaal, Northern Rhodesia, Tanganyika, Kenya, Uganda, the Sudan, and Algeria, and as a result thirteen volumes on African subjects have been published. As a secondary means of achieving its aim, the institute has awarded a number of studentships to administrative officers, educationalists and missionaries, who had already experience in Africa, to study anthropology in London. The Rockefeller Foundation has also materially assisted African anthropology by the grant of fellowships for field work. Similar assistance to the science has been rendered by the Leverhulme Trust.

In recent years a number of geographers, headed by Professor Roxby and Professor Ogilvie, have stressed the importance of the material background or environment in the study of anthropology, and have pointed out that many published anthropological studies of the past do not take full cognizance of this background. Seeing that Africa offered a unique field for an inquiry into this subject, and that many officials and other residents in the colonial dependencies were already familiar with the data required, a committee of the British Association was formed to study the human geography of intertropical Africa. Its work has been discussed in Chapter XI, p. 304.

The study of material culture as a branch of anthropology has tended to attract less attention in recent years. Nevertheless, anthropological studies cannot afford to neglect material culture, since in any improvements which are to be imposed on the African's material position in the world, an understanding of his relationship to a particular environment is all important; and this

relationship is often expressed in artifacts, particularly those which the African uses for obtaining food. Moreover, the study of such artifacts, when their functional aspect is stressed, can often lead to conclusions regarding the adaptive or inventive ability of a given people. For the study of material culture and also for that of archaeology, museums are essential, so a few of the most important ethnographical collections may be mentioned. In Great Britain the British Museum is in a leading position for purposes of archaeology, but for systematized material culture the Pitt-Rivers Museum at Oxford has been placed in an eminent position by the activities of Professor Henry Balfour. The Museum of Archaeology and Ethnology at Cambridge, formerly under the curatorship of Dr. Louis Clarke, who has carried out studies in the field on several occasions, particularly in Abyssinia, is likewise important, and the ethnological collections under Mr. R. U. Sayce at Manchester are of high value. The Musée du Congo Belge at Tervueren has unique collections of African material culture, with a large staff of workers devoted to their arrangement, sorting, and analysis. Dr. Lindblom and his assistants at the Stockholm Museum are at present producing a series of studies on special artifacts, such as fish hooks, fish baskets, game traps, etc., with the object of showing their origin, distribution, and evolution in the whole continent of Africa.

It is certain that one or two whole-time anthropologists attached to the administrations of each of the larger colonies would be of great value, but the exact form which such an organization should take for the greatest efficiency is a matter for debate. Special pieces of *ad hoc* research, on such subjects as the effects on particular native societies of new legislation, are continually being required by administrative departments, so that official anthropologists as government servants would have no lack of occupation. On the other hand, in anthropology even more than in other sciences, the research worker should be enabled to direct his own activities, and since native life itself is his material, it is desirable that he should be free from association with the administrative activities, the effect of which forms part of his field of study. For these reasons it may be undesirable that anthropologists should be absorbed directly into the colonial or dominions services. The

ideal organization for anthropology in Africa might be envisaged as a central institute in Great Britain, much on the lines of the existing International Institute of African Languages and Cultures, but supported largely by Government funds and maintaining anthropologists permanently in the African territories. These officers could be called upon by local governments in any special circumstances, but, for most of their time, would be left to build up a foundation of fact and theory for permanent reference by the administrative and technical departments.

PRE-HISTORY

Africa may have been the cradle of the human species, a view advanced a long time ago by Charles Darwin and others, and given strong support by the discovery of the Taungs skull (*Australopithecus*) in the Transvaal in 1924 by Professor R. Dart. Sir G. E. Smith pointed out that this skull, though that of an ape, more nearly resembles man than does any other ape. Dr. R. Broom (1936) has thrown further light on the subject by the discovery near Krugersdorp of an advanced type of ape, which appears to be nearly related to that from Taungs.

That some sort of man inhabited Africa very early in pleistocene times is proved by the stone implements discovered in many parts of the continent. These have been correlated with tools found in Europe, but the correlations have not always stood the test of time. As a generalization it may be claimed that, with certain regional modifications, the sequence of cultures in Africa appears to resemble the sequence in Europe, but this does not imply contemporaneity of cultures, nor the racial identity of the peoples associated with them. In interpreting these results, which are involved with questions of past climates and geological change, Burkitt (1928) for South Africa, Wayland (1934) for Uganda, Leakey (1931 and 1934) for Kenya, and Miss Caton-Thompson (1934) for the Fayum have been the chief workers. In West Africa P. Laforgue (1931) has given a preliminary account of the Stone Age. During the pleistocene, Old Stone Age tools were shaped only by chipping. At the end of the pleistocene the New Stone Age saw the grinding and polishing of tools and also the

practice of agriculture, domestication of animals and manufacture of pottery. Remains have been found over the greater part of the continent.

Passing to human remains, some of which have been found associated with Stone Age cultures, Rhodesian man, *Homo rhodesiensis* (Elliot Smith 1927), from Broken Hill is perhaps the most primitive of the human family, which includes the lower genera *Pithecanthropus* and *Eoanthropus*. The Kanam man, *Homo kanamensis*, represented by part of a jaw from the Kavirondo Gulf, Lake Victoria, was described by Leakey (1935) and claimed to be the most ancient fragment of true *Homo* found anywhere in the world. Kanjera man, from the same region, is somewhat later, and better represented by pieces of skull, etc. Leakey holds that the two demonstrate the existence of *Homo sapiens* long before the time when the Neanderthal people spread over Europe. Professor Boswell and others, however, cannot agree that the dates of either the Kanam or Kanjera men are yet proved. Oldoway man, found by Dr. Hans Rech in Tanganyika in 1913, has also been the subject of much controversy, but is now generally held to have been buried and therefore its true date can never be proved.

Later remains of the Neolithic include those found in 1927 at Elmenteita in Kenya Colony by Leakey, on the Springbok Flats in the Transvaal by Broom in 1929, and near Asselar in the French Sahara in 1927, proving that man lived in this region when it was not desert. Other remains discovered in South Africa can be divided into three classes: Boskop, Fish Hoek, and Australoid man. None of these remains show the characteristics associated with the pure negro type (Smith 1935), but it has to be remembered that the existence of a negro stock, from which such types are presumed to be developed, is itself an hypothesis; these remains may point to a revision of assumptions now generally made with regard to the migrations of peoples of various types through Africa, but they might equally lead to a revision of existing theories on the subject of racial stocks.

RACIAL TYPES

Leading on from the fossil remains of man it is necessary to refer to some recent work on the existing races of Africa before

proceeding to the aspect of cultural anthropology which has more direct bearing on other sciences. Dr. A. C. Haddon (1924) divides Africans into those with woolly hair (Ulotrichi) and those with wavy hair (Cymotrichi), and subdivides these two groups according to stature, colour of skin, shape of head, and again, according to shape of nose. The more usual, but less technical, grouping is that of Professor Seligman (1930) into

White race	Hamites Semites	of common origin
Negro race	True negroes Mixed negro-hamitic	
Negritos		
Khoisan	Bushmen Hottentots (predominantly bushman-hamitic)	

The first two of these major races, the white or Europid (Caucasian) and the Negro, have numerous subdivisions and have suffered continued interactions. By comparison, the Negritos, Bushmen and Hottentots, though of great academic interest, have played but a minor part in the history of the continent.

Recent work on cranial measurements and blood-groups suggests that the true classification is by no means so simple as the scheme given above. Moreover, there has been confusion, owing to different opinions by experts, as to what is meant by the concept of a race; sometimes a linguistic group, such as the Bantu, has been referred to as a racial type, but the criteria for distinguishing races should really be physical, not cultural. In the words of Professor Seligman: 'It seems obvious that the question of race should be determined by the study of physical characters, yet in no part of Africa is there in existence anything approaching an anthropological survey (based on such characters), nor can it be said that for any considerable area more than the first rough survey work has been done.'

Although physical data are available from many parts of the continent, most have been collected by amateurs who have used different standards, so that the value of their work lies chiefly in

its indication of the complexity of the problem which has to be solved. Data on the cephalic index are probably the easiest to collect, since measurements can be made on the living head; some data for central Africa were obtained by Struck (1922) and illustrated by 'contour lines' on a map which, however, is somewhat misleading, as the areas where no observations were made, form the larger proportion of the total shown. While it may be possible to determine some degrees of relationship from a study of the living, direct evidence of this type bearing on racial genealogies can only be collected from skeletons. Skulls are more easily procurable in large numbers than other bones, and have, therefore, received most attention from the anthropological point of view. For example, Miss Elisabeth Kitson (1931) has compared the measurements of one hundred and twenty skulls found by Dr. Leakey in the Teita region of Kenya with the measurements of six hundred skulls published by other workers. No sharp distinction can be drawn between the negro races of Western, Eastern and Southern Africa. The Teita skulls are more closely related to those of the Nguni and Hottentots than to those of their neighbours in Tanganyika, while the latter resemble the Galla and Somali, and the early negroid skulls from Egypt. A clear differentiation between Bushmen, Hottentots, and Kaffirs was observed. These observations serve once again to emphasize the complex ancestry of the present African peoples.

The discovery of differences between the blood of various peoples and the recognition of blood-groups, made in 1919 by L. and H. Hirszfeld, provides a new method of approach in classifying races. It depends on the principle that the transfusion of serum from one person's blood to that of another may cause the red corpuscles to agglutinate. Research has led to the classification of all humans into four groups or seriological races, but opinion is divided as to whether this division came about as a result of inheritance from anthropoid ancestors or from the evolution of man himself. Edwin Smith (1935) has collected published results on about 8,500 Africans in a table showing the percentage of each of the four groups in the tribes studied. The principal conclusions are that Bushmen belong predominantly to the blood-group which is regarded as the most primitive, and that the Bantu exhibit marked variation, indi-

cating a mixture of races. R. Elsdon-Dew concludes from his studies in South Africa (1934a, 1934b, 1935) that the Hottentot may be a mixture of Hamite and Negro, with a variable proportion of Bushman blood. His latest results on the Bantu are published in a recent book (1937) in which he makes suggestions, based on this line of research, regarding the early racial history of African peoples as a whole. Blood-groups and their significance were discussed at the international anthropological congress in London (Congrès 1934), when it was concluded that results, to represent a criterion in racial classification, must be correlated with other physical characters which are equally valid.

HISTORY AND MATERIAL CULTURE

Interaction of races and cultures must have begun in Africa during the Neolithic Age, say 3,000 B.C., but until the opening of the modern epoch in African history in the seventeenth century, when the Dutch occupied Table Bay and various European nations established trading posts along the Guinea coast, written records concerning Africa south of the Sahara were confined to occasional references in Arabic literature. Accordingly deductions as to the past five thousand years can, for the most part, be made only from Africa as we see it to-day, from ascertained facts about languages, racial types, domestic animals, cultivated plants, artifacts, ruins and native traditions. As in the case of the pre-history of the continent, different interpretations have been put on the discoveries made, and in most cases knowledge rests on hypothesis rather than certainty.

Taking these categories of evidence in the order set down above, similarities of language have been used extensively in piecing together historical events; as an example, the close resemblance between the different Bantu tongues and their relationship to Sudanic is taken as an indication of a migration of peoples from the north of the Bantu line. Thus a name for the domestic fowl, *Kuku*, shared by many tribes, led Sir H. H. Johnston (1919) to think that this migration followed the introduction of the bird into Egypt from Persia in 525 B.C. Attempts have been made to construct the original Bantu language on the assumption that the

modern variations are derived from one original tongue. Inferences from an examination of the ur-Bantu roots are that, prior to their separation, the people kept cattle, not sheep, cultivated the soil, used canoes, that they had the idea of taboo and believed in ghosts.

The common possession of such cultural traits has often been quoted as evidence of a common racial origin, a method of reasoning criticized by Edwin Smith, who suggests that there has been a tendency to exaggerate the importance of 'Hamitic blood'. C. G. Seligman (1930) holds that, apart from Semitic influence, African history is a record of the Hamites and their mingling with the more primitive Negroes and Bushmen. Others, including Torday (1930), think that Bantu civilization cannot be due to the ancestors of such primitive pastoral Hamites as the Hadendoa and Beja, ignorant, as they must have been, of agriculture, arts, and crafts. The existence of the two racial stocks, Hamite and Negro, is itself an inference from superficial traits and from the present distribution of the people. It is thought that the brown Hamites spread over North Africa, intermingling with Negroes, and thus formed a series of hybrid peoples. J. H. Driberg (1930) has put forward a reconstruction of this movement. The unrest and warfare which must have occurred about the beginning of the sixteenth century, when the Portuguese were attempting to gain control in Ethiopia, involved various peoples, including the Galla. These disturbances started the Shilluk warriors and pastoralists on their wanderings north and south, till they invaded the fertile plains to the west of Lake Victoria. There they dominated the Bantu agriculturalists and established the kingdom of Kitara in Ruanda-Urundi, and Ankole, from whence it spread to Buganda and Bunyoro. They set themselves up as an aristocracy over the conquered peoples, with a king and a royal family. Gradually separate kingdoms were created, and the resultant cultures varied according to the number of the invaders in the different regions. Thus in Ankole, the two peoples have kept distinct to the present day, whereas in Buganda there was a blending of cultures.

The date of the entry of the Semites, the other branch of the white or brown race, into Africa is unknown, but the migration of Arabs into Ethiopia was probably at its height between 1500

and 300 B.C. In later centuries these migrations brought Islam with them, thereby exerting a profound influence on the continent. Another important influence on African culture has been the existence of trade routes between the Mediterranean littoral and the Sudan lands via the Sahara; these routes and their effects are discussed at length by E. W. Bovill (1933). The origin of the Tuareg of the Sahara, with their camels and their unique script, is another unsolved problem in the history of Africa; it has been considered by Sir H. R. Palmer (1932) and F. R. Rodd (1926).

The deductions made from a study of domestic animals in relation to the history of Africa are surveyed by Sir H. H. Johnston (1911). It is noteworthy how few of the domestic animals are indigenous. For example, the horse, humped Zebu cattle, sheep, goat, and two-humped camel were first tamed in Asia and subsequently introduced to Afiica. The horse, associated chiefly with the Islamic invasion, did not spread to the same extent as goats and oxen because the forest-belts served as a barrier. Edible plants have likewise been introduced to the continent from abroad, many from America in modern times, others from the East, probably brought by Arabs and Portuguese (*see* Chapter XII). Edwin Smith concludes that the presence of certain animals and plants in different regions does not prove that any considerable migrations took place, but that they were introduced by trade or by conquering peoples in tribal warfare. The fact that so few native animals have been domesticated and so few indigenous plants cultivated suggests that the early inhabitants of the continent had little interest in agriculture.

Turning to hand-made objects and ruins, many discoveries have been made and many conjectures have been based on them. From museums have emanated maps showing the distribution of many artifacts, such as the *Atlas Africanus* by Leo Frobenius and Ritter von Wilm (1921 onwards). Better perhaps are those pamphlets, which indicate the actual places where objects have been found, issued by the Riksmuseet, Stockholm, mostly by K. G. Lindblom, showing the distribution of fighting-bracelets, fish-hooks and other fishing gear, the spiked wheel-trap, the use of oxen as pack and riding animals, and of the hammock. Similar maps for the Belgian Congo have been published by the Musée du

Congo Belge at Tervueren. Theories with regard to earlier contacts are based mainly on evidence of this kind; thus in relation to the influence of ancient Egypt, Sir G. Elliott Smith and others have traced similarities in artifacts between Egypt and parts of East Africa. Professor Seligman (1934) concludes that the cultural similarities between ancient Egypt and Negro Africa are the result of a wide diffusion of old Hamitic ideas, rather than of direct borrowing. He cites the harps and a long-necked lute from West Africa which are identical in certain details with examples from ancient Egypt. He has also traced the Egyptian rite of killing the Divine King to Uganda, the northern Transvaal and West Africa. Another line of external influences has been traced from Indonesia via Madagascar to the East African coast and inland even as far as the great lakes. The existence of cultural similarities between different peoples, however, may be alternatively explained as a result of independent invention. The view characteristic of early writers on material culture was that certain peoples have been incapable of invention, so that similarities are *prima facie* evidence of external contacts in the past. To take an example, a unique type of canoe made by the Baganda of Lake Victoria has in the past been held by various authors as evidence of ancient Egyptian influence on the one hand and Indonesian influence on the other. A detailed study of all the canoes on this lake (Worthington 1933 and Fosbrooke 1934) demonstrated, however, that the Baganda canoe is really the climax of a series leading up from the simple dug-out, each member of the series showing progressively better adaptation to the peculiar conditions obtaining on that lake. In this case there seems to be evidence of the ingenuity and adaptability of the local craftsman, and similar examples could be given for many tribes.

On the other hand, there are many instances in which contact between more than one race, emigration, or direct borrowing, have been proved to account for similar objects or customs. For instance, the beads resembling those of South India dating to the eighth or ninth century A.D., discovered at Zimbabwe in Northern Rhodesia by Miss Caton-Thompson (1931), can be attributed to the Arabs who settled on the coast of East Africa in the seventh century and probably traded with India. Dr. Lindblom, in the Riks-

museet pamphlets mentioned above, has given several examples of diffusion, and Hornbostel (1933) has studied sound instruments with the same object.

Finally, evidence derived from native tradition is usually unreliable, unless such information can be checked by comparison with known historical facts or astronomical data. For example, Torday was told that during the reign of one of the Bushongo chiefs the sun went out at noon. He was able to fix the date when he found that the only visible eclipse in this region during the seventeenth and eighteenth centuries occurred exactly over Bushongo country at two minutes before noon on 30th March, 1680.

In conclusion it may be said that the evidence from all these sources indicates movement among the peoples of Africa during the four thousand years under consideration, resulting in the transmission of ideas and cultures and the growth of new languages, with probably long intervening periods of comparative stagnation.

SOCIAL ANTHROPOLOGY

The study of African social life and of the changes which are taking place as a result of culture contact, bears the closest relation to the other scientific subjects, since it looks at the present and future of native races rather than at their past. Consequently, in attempting to estimate the resources in anthropology which can be directed to Africa's future, the emphasis will here be laid upon those workers who stress the functional and dynamic rather than the structural and static aspects of the subject. Professor Malinowski has aptly compared the old type and the new type of anthropology with anatomy and physiology. We might go a stage further and point out that anthropology is still so large and diffuse that, by comparison with other sciences, many years must pass before it will find its way through the preliminary observational stage to the experimental stage, now reached by many physical and biological sciences, when individual problems can be formulated with precision and can be driven to a logical conclusion by experiment under controlled conditions. The first stage in the slow evolution of the science is the establishment of definite methods of research, and in recent years anthropologists have made great

advances in this direction, so that already many of the results are set out in a form which offers itself for application to other fields. The following paragraphs consist of little more than a sketch of some of the significant literature produced to date, following the classification of tribes given in Torday's (1930) large and valuable compilation of the cultural data concerning the indigenous tribes of Africa. The summary is taken mainly from Smith (1935) with some additions.

For the Southern Bantu a sub-committee of the Inter-University Commission for African Studies, with Professor I. Schapera as editor, has produced a volume (1934) of essays by various experts in South Africa on the effects of Western civilization on the South African Bantu, and there is another important joint volume under the same editorship (1937). Schapera's own book (1930) provides an account of the Bushmen and Hottentots, and he has also published a full bibliography of all available literature on South African tribes (1931 onwards). Vedder's monograph on the Bergdama (1923) is another valuable ethnographical study. A further important study of a South African tribe, primarily concerned with the effects of contact, is on the Pondo by Monica Hunter, now Mrs. G. Wilson (1936), whose work was made possible by a Fellowship from Cambridge University. Miss Hilda Beemer made a study of the Swazi with the assistance of a Fellowship from the International Institute of African Languages and Cultures. H. Junod, a Swiss missionary in Natal and Portuguese East Africa, produced in his accounts of the Thonga (1924 and 1927) one of the most important existing studies of a Bantu people. Callaway's book on the religious system of the Zulu (1868–70) and Stayt's work on the Bavenda (1931) are outstanding. J. H. Soga (1930 and 1931) has written monographs on the Southern Nguni. Fuller accounts of the Zulu, Sotho, Ambo and Herero are still required, though E. J. Krige (1937), a trained anthropologist, has collected existing material relating to the Zulus. Bullock's book on the Shona tribes of Southern Rhodesia (1928) needs to be supplemented. Smith (1935) stressed the necessity for monographs on the connection between Shona culture and the Zimbabwe ruins, and between the Rozwi of Mashonaland and the Rotse of the Upper Zambesi. Dudley Kidd (1906), working among the Bantu

of Southern Africa, is one of the few who have studied native children. In a different type of community, which has grown up under white influence, Mrs. Hellman (1934) has given some interesting data on a native urban group, and Mrs. Krige (1936) has also investigated the urban native communities of South Africa. Lastly, Schapera emphasizes that, though there is much information on cultures themselves, studies of the Africans as individual human beings are for the most part lacking. In this connection, Miss Perham's (1936) collection of autobiographies by ten Africans is valuable.

For the Central Bantu, who inhabit Northern Rhodesia and the Belgian Congo, C. M. Doke (1931) has contributed a monograph on the Lamba, Melland (1923) has written on the Kaonde, and Smith and Dale (1920) have produced two volumes on the Ila-speaking peoples. Gouldsbury and Sheane have made a slight sketch of the Awemba (1911). More recently Dr. Audrey Richards (1932) published a general study of the place of food production and distribution in the culture of the Southern Bantu, and has made extensive field studies, during two periods of work in 1930–1 and 1933–4, of the Bemba and Bisa, the full results of which have not yet appeared: Dr. Richards has published a number of preliminary articles in *Africa* and the *Journal of the African Society*, dealing among other subjects with native diet and chieftainship under indirect rule (*see* Chapter XVII). Godfrey Wilson (1936), formerly a student of the International Institute of African Languages and Cultures, and later a Rockefeller Fellow, has also worked in this region on the Nyasaland-Tanganyika border. From 1907 to 1913 a series of books was published, under the direction of van Overbergh, dealing with the Congo tribes. These are of unequal merit, the best being that by Colle on the Luba (1913). Accounts of some sections of this tribe have been given by Torday and Joyce (1910 and 1922), and the former has also described the Bushongo (1910). Other books include those by Weeks (1913 and 1914) on the Bangala and the Kongo, van Wing (1921) on the Kongo, and Hambly (1934) on the Mbundu of Angola.

Early surveys of the Eastern Bantu of Nyasaland were made by Sir H. H. Johnston (1897) and Dr. Alice Werner (1906). An even earlier work by Macdonald (1882) provides a useful account of

the Yao before they came much in contact with European civilization. T. Cullen Young (1931) published a valuable volume on the Tumbuka–Kamanga peoples. Mackenzie (1925) has made a slight sketch of the Konde in Tanganyika, and Bruno Gutmann (1928 and 1932) has studied the social structure and laws of the Chagga, with special reference to education. His work is supplemented by that of Dundas (1924) and Schanz (1913). Among other German authorities may be mentioned Blohm (1931 and 1933) on the Nyamwezo, Dempwolff (1916) on the Sandawe, Claus (1911) on the Gogo, and Karasek (1911–24) on the Shambala. A recent work by A. T. and G. M. Culwick (1935) on the Bena is notable. Hobley (1910) and Lindblom (1920) have described the Kamba in Kenya; the former has also discussed the Kikuyu magical beliefs. Major G. St. J. Orde Browne (1925) has given a general account of some minor tribes of the colony. G. Gordon Brown held a Rockefeller Fellowship for work among the Hehe of Tanganyika, and, in collaboration with Mr. Hutt, an administrative officer, has concentrated on the relationship between anthropology and administration; their joint book (1935) provides an admirable picture of this subject. Two Fellows of the Institute of African Languages and Cultures have recently been at work in the same general cultural area: Dr. Wagner, among the Maragoli, a tribe of the Bantu in Kenya, and Dr. Oberg among the Nkole.

The tribes living in the lake region of Uganda and Ruanda were included with the Bushongo in Torday's division 'Bantu under Alien Rulers'. Canon J. Roscoe collected a mass of data on the material culture and political organization of several of these tribes. His most important work is that on the Baganda (1911). Dr. Lucy Mair (1934) has stressed particularly the changes among the Baganda resulting from European influences.

The tribes inhabiting the area from the Upper Nile to Tanganyika, classified by Torday as Nilo-Hamites, have been dealt with by Seligman (1932), who described the northern members, and by A. C. Hollis, who wrote on the Masai (1905) and the Nandi (1909). A German work on the Masai is that by M. Merker (1910). An account of the Suk was given by Mervyn Beech (1911). More information is available on the Nilotic tribes in works by Hofmayr

(1925), Westermann (1912) and Huffman (1931), while Driberg (1923) made a valuable study of the Lango.

The 'Equatorial hybrid tribes' include the Negroes inhabiting that part of the continent bounded by the Nile-Congo watershed on the east and the Gulf of Guinea on the west. Dr. Evans-Pritchard's work on magic among the Azande (1937) is an exhaustive study of an aspect of native culture which is important in all areas. This people has also been described by Calonne-Beaufaict (1921). Little is known of the Gabon and Cameroon tribes; the most comprehensive work yet published is that on the Fang by Tessmann (1913) and he has also given an account of the Baja (1934).

Included in Torday's Central Sudanic section are the tribes of Nigeria and part of French West Africa. For the Southern Provinces Talbot's survey (1926), made at the time of the 1921 census, is important, while C. K. Meek has performed a similar service for the Northern Provinces (1925). In addition, he has published an ethnographical survey of the Jukun-speaking peoples of Nigeria (1931a) and a series of reports on more than fifty non-Moslem tribes (1931b), which illustrate some of the special administrative problems which have to be faced. R. C. Abraham (1933) and R. M. Downes (1933) published work based on reorganization inquiries among the Tiv people. Dr. Nadel (1935a, 1935b, and 1937), holding a Fellowship from the International Institute of African Languages and Cultures, studied the Nupe tribe in the Northern Territories of Nigeria during 1935 and 1936. He was concerned specially with systems of chieftainship and has been able to assist the administration with regard to changes in indirect rule. His results are not yet fully published. Miss M. M. Green and Mrs. S. Leith-Ross, both working as Leverhulme Trust Fellows during 1934–5 and 1936–7 among the Ibo people of south-east Nigeria, made respectively intensive and extensive studies. The former's results are not yet published; the latter's have been shown in *Africa* and in a volume on Ibo woman (1939). It should be added that Miss M. F. Perham's studies in various parts of Africa on native administration and in particular her detailed work on Nigeria (1937) have done much to illustrate the place of social anthropology in administration.

Turning to the western Sudanic peoples, Captain Rattray's

books (1923, 1927, and 1929) on Ashanti customs, religions, and laws are notable examples of the work of a Government officer. He also (1932) produced two volumes on the tribes of the Northern Territories of the Gold Coast. Spieth (1911) has written on the Ewe of West Africa. Dr. M. Fortes, a Fellow of the International Institute of African Languages and Cultures, has worked among the Tallense in the Northern Territories of the Gold Coast, and has published papers on food (with Mrs. Fortes), fishing activities, marriage customs, and the main lines of internal change (*see* Chapter XVII). Edwin Smith, following Labouret, suggests that more work on the whole culture of the peoples of this part of the continent is needed. Hitherto there has been a tendency to concentrate on folk-lore to the exclusion of more important aspects of the problem. This criticism does not apply to Labouret's books on the Lobi and the Mandingo (1931 and 1934). For the Ivory Coast there are publications by Tauxier (1921, 1924 and 1932), while surveys of Dahomey and the French Niger Colony have been produced by A. Le Hérissé (1911) and Maurice Abadie (1927), and preliminary work by M. J. Herskovits (1933 and 1937). The late Maurice Delafosse worked for many years in French West and Equatorial Africa and his volumes, especially *Haut Sénégal-Niger* (1912), are classical books; his more popular works, designed to interest the general public in Africa, are admirable of their kind; a particularly useful one is *Les Civilisations Négro-Africaines* (1925). L. Geismar (1933), a senior administrative officer in French West Africa, published the first completed study of the customary law of a colony. For the peoples of Liberia there is a general survey by Sir H. H. Johnston (1906) and a monograph on the Kpelle by Westermann (1921). Sierra Leone has been cursorily dealt with in a travel book by F. W. H. Migeod (1926). Dr. Hofstra (1933 and 1937), working in Sierra Leone as a Fellow of the International Institute of African Languages and Cultures, has made detailed sociological studies.

The Fulani are classified by Torday as a separate group, and many brief accounts of their history and customs exist, that by Wilson-Haffenden (1930) being perhaps the most important. Another separate group is formed by the Bambuti or pygmies, for which Schebesta's work (1933) is the most complete.

Among books on special subjects may be mentioned those on modern sculpture by Georges Hardy (1927) and a general work on art in West Africa by Sir Michael Sadler (1935). Music has been studied by E. M. von Hornbostel (1933), while Bantu folklore has been described by Dr. Alice Werner (1933) and the legends of other peoples have been included in many of the books already cited. Willoughby (1928) and Sir James Frazer in his Gifford Lectures (1926) have written on religion, and Driberg (1935) has studied the African conception of law. In addition to the works mentioned above there are, of course, many valuable articles on social anthropology scattered through the pages of scientific and other journals, notably the *J. R. anthrop. Inst.*, *Man*, *Africa*, the *J. Afr. Soc.*, *Lond.*, *Sudan Notes and Records*, the *Uganda J.* and the *Bull. Com. A.O.F.*

This review of the existing literature serves to show how much work remains to be done. Edwin Smith suggests that the most pressing requirements are: (1) A handbook of tribes for the whole continent, which would presumably be somewhat on the lines of Torday's work (1930), but on a less ambitious scale. The International Institute of African Languages and Cultures undertook to prepare such a book, but the enterprise was given up. (2) A series of synthetic and critical studies on a regional basis, collecting all available information and supplementing the handbook. These would include the material stored up in the books of Government officers as well as that in various periodicals. An example of such a volume is Schapera's *Khoisan peoples of South Africa* (1930). (3) Additional comprehensive studies on individual tribes, including ethnographical accounts of family life, education and agriculture (4) Further research on African cultures as they are to-day, in a state of transition, taking full account of the degree of disintegration or reintegration of culture, economic and ethical systems, agriculture, etc., which has resulted from European influence. Of these desiderata, perhaps most emphasis may be laid on the last.

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EXPLANATORY NOTE

THE bibliography is arranged under Chapter headings II to XVIII, except that references in Chapters XI to XIV (Agriculture) and XV to XVII (Health and Medicine) are grouped together. Details of the reference system are in accordance with the suggestions made by a Committee of the Royal Society in 1936, but with certain modifications. Under each heading the names of authors or territories are arranged alphabetically and followed by the year of publication, except in the case of annual reports, either general or departmental, which are referred to by the year to which the report has application, and distinguished by the letters *A.R.* (general annual report) or *D.R.* (annual departmental report) placed after them. In cases where several papers published by one author in the same year are cited, small letters, a, b, c, d, etc., are placed after the date to indicate which paper is being referred to. Titles of papers and of books are in roman type. As far as possible the short titles of periodicals, printed in italics, are those given in the *World List of Scientific Periodicals* (1934): volume numbers are printed in bold-faced type, and the beginning and end pages of papers are given in most cases.

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CHAPTER VII. FORESTRY

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CHAPTERS XI–XIV. AGRICULTURE

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PHYSICAL MAP OF AFRICA
English Miles
VEGETATION
Desert
Hill and Plateau Grassland
POLITICAL DIVISIONS
EXPLANATION OF COLOURING
NORTH ATLANTIC OCEAN
GULF OF GUINEA
SOUTH ATLANTIC OCEAN
INDIAN OCEAN
AZANIAN SEA
BLACK SEA
MEDITERRANEAN SEA
FRANCE
SPAIN
PORTUGAL
YUGO SLAVIA
BULGARIA
GREECE
TURKEY
ARABIA
MOROCCO
ALGERIA
TUNISIA
LIBYA
EGYPT
FRENCH WEST AFRICA
NIGER COLONY
SENEGAL
FRENCH SUDAN
LIBERIA
GOLD COAST
ASHANTI
NIGERIA
CAMEROONS
ANGLO-EGYPTIAN SUDAN
UBANGI-SHARI
BELGIAN CONGO
UGANDA
KENYA
BRITISH SOMALILAND
ITALIAN SOMALILAND
TANGANYIKA TERRITORY
ANGOLA
NORTHERN RHODESIA
SOUTHERN RHODESIA
MADAGASCAR
SOUTH WEST AFRICA
Bechuanaland Protectorate
TRANSVAAL
UNION OF SOUTH AFRICA
CAPE PROVINCE
Kalahari Desert
Fezzan
Ogaden
Hadhramaut
Gulf of Aden
Damaraland
Lunda
Gaza Land
Capetown
Tropic of Capricorn
Equator